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Gulf River Estuary Natural Resources Inventory

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GULF RIVER ESTUARY

Natural Resources Inventory

Final Report
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Prepared for the Gulf Association, North Scituate, Massachusetts

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1. INTRODUCTION

The purpose of this analysis is to inventory the present assemblage of natural resources in the vicinity of the Gulf River estuary as well as to provide information on land use, recreational use, and pollution threats and concerns. The inventory summarizes existing research and the knowledge and experience of local experts and residents who are most familiar with the Gulf River's natural environment. It could be used as the first step toward producing a resource management plan for the Gulf River estuary.

The analysis was initiated and funded by the Gulf River Association and prepared to serve as a reference for the Association, as well as local and state officials and citizens who are committed to protecting the ecosystem and to making the most of what their natural environment offers. The inventory provides the necessary background to prioritize additional research needs and to assess existing local environmental and land use management practices and policies.

The document presents both anecdotal and scientific data relating to watershed characteristics, history of the region, habitats of the Gulf River estuary, geology and soils, biological resources, water quality, land use, open space and recreation, and environmental quality concerns and pollution sources. Interviews with local resource professionals and residents supplemented the literature review of existing reports and studies.

1.1. STUDY AREA

The Gulf River is an estuary between the towns of Cohasset and Scituate in southeastern Massachusetts, which drains into Cohasset Harbor and subsequently into Massachusetts Bay. The Gulf River is considered a major salt water feature of the region, along with Cohasset Harbor, Little Harbor, Straits Pond (Cohasset Open Space Advisory Committee 2001), and Musquashcut Pond and is one of three tributaries of Cohasset Harbor. Included in the study area for this natural resource inventory of the Gulf River basin is that portion of the estuary extending from the Border Street bridge in Cohasset to Musquashcut Pond in Scituate, as well as all wetland, stream, and upland features within 1,000 feet of the Gulf shoreline (Figure 1-1). A region limited to the immediate vicinity of the Gulf River estuary was singled out as the primary study area based on the expressed interests and concerns of the Gulf River Association. A 1,000 foot buffer was selected based on aerial photography, topography and resource maps, because it provides a combination of natural resources and physical features that are typical of the region. In addition to providing a resource analysis for the study area, certain issues are discussed on a broader watershed scale. The Gulf River estuary watershed delineated for this project is described below.

The study area was approximated at 1,260 acres, as calculated using ArcView GIS software in combination with US Geological Survey (USGS) digital elevation models, and field verified using a more traditional dot grid area calculator and USGS Quadrangle Topographic maps (the study area is contained within the Cohasset and Scituate USGS topographic maps). Bathymetric data (i.e., ocean depth), which is collected by the National Oceanic and Atmospheric Administration for navigational charts, was not available for the Gulf River estuary.

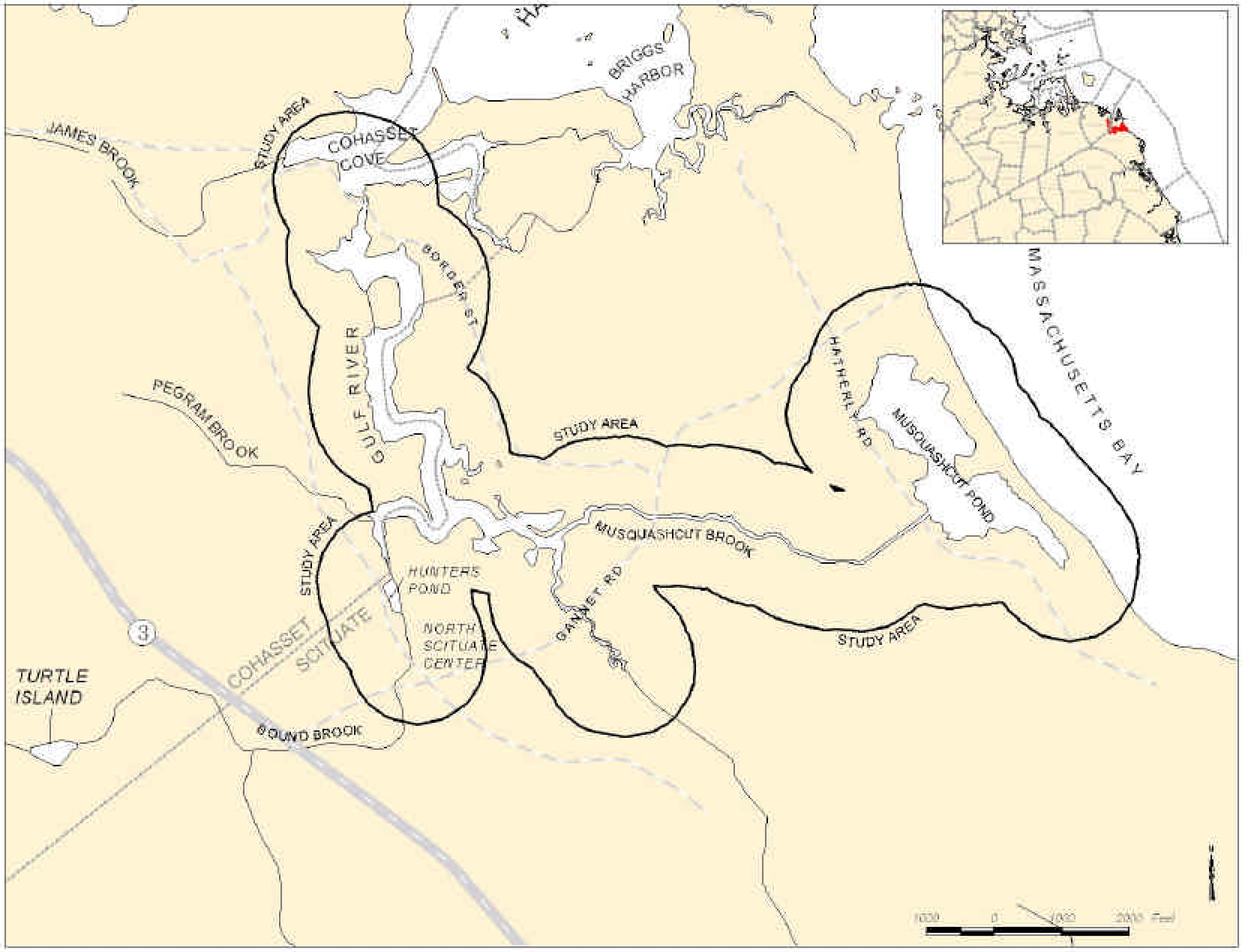

Figure 1-1. Gulf River Estuary Study Area and Locus Map.

1.2 GULF RIVER ESTUARY WATERSHED

A watershed can be defined for any body of water (e.g., stream, river, lake, ocean) as all the surrounding area wherein a drop of water falling on the surface eventually finds its way into the water body. When speaking in watershed terms, this water body is referred to as the *receiving waters*. Watersheds can be small or large, depending on the size of the receiving waters, and they can contain numerous other water bodies within them. For this reason, a number of small watersheds are often contained within larger ones. The terminology for watersheds is not used consistently; other words that mean the same thing include basin, drainage basin, and catchment.

The Gulf River estuary was delineated for this report using a Geographical Information System (GIS) (ArcView 3.2) in combination with additional spatial analysis software (Spatial Analyst 2), as well software designed by MassGIS for the purpose of studying watersheds (Watershed Analyst extension for ArcView). The watershed was identified using digital elevation models [1] obtained from the US Geological Survey, which in turn were used to develop slope and aspect grids. Slope grids contain information on the steepness of elevation changes and aspect grids contain information on the compass direction of a particular slope. In combination, these data can be used to determine the land area where all water is directed towards, and drains into, the Gulf River estuary.

The Gulf River watershed is illustrated in Figure 1-3. It is a small watershed contained within the larger South Coastal watershed (see inset map in Figure 1-3), which extends along the eastern coast of Massachusetts from Cohasset to Plymouth. The Gulf River watershed covers an area of approximately 16 sq. miles (42 km^2) and encompasses portions of the municipalities of Cohasset, Scituate, Hingham, and Norwell. The percentage of municipal land area contained within the watershed is presented in Figure 1-2.

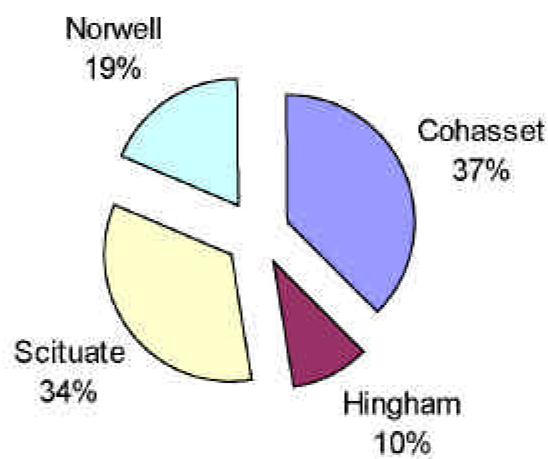

Figure 1-2. Percent Land Area of Each Town Within Gulf River Estuary Watershed.

There are several significant hydrographic features in the Gulf River watershed (see Figure 1-3). *Lily Pond* has been used as the Town of Cohasset's drinking water supply since 1880. It is approximately 52 acres in size and can store up to 170 million gallons of water (Norfolk Ram Group 2002). Two tributaries, *Peppermint Brook* and *Brass Kettle Brook*, feed into the pond and the *Herring Brook* serves as the ponds natural outflow. The *Aaron River Reservoir* is an artificial water body that formed in 1978 when a dam was erected to control flow in the *Aaron River*, the main tributary to the Reservoir. The Reservoir is located one mile south of Lily Pond and is

[1] A Digital Elevation Model (DEM) is a digital representation of a portion of the Earth's surface, derived from elevation measurements at regularly spaced horizontal intervals.

hydrologically connected to the pond by a sluice gate at *Bound Brook* that is used to control water elevations in the Brook (Norfolk Ram Group 2002). Outflow from the Aaron River Reservoir into the Aaron River is controlled by a slide valve that controls flow over a fish ladder at the Reservoir dam (Norfolk Ram Group 2002). Bound Brook begins where the outflows from both Lily Pond and the Reservoir converge and extends to Hunter Pond.

The *Surface Water Supply Protection Plan for Lily Pond and Aaron River Reservoir* (2002), which was recently completed by Norfolk Ram identified a lack of information concerning flow in the tributaries of Lily Pond and the Reservoir and recommended that a comprehensive hydrologic assessment of the region should be completed.

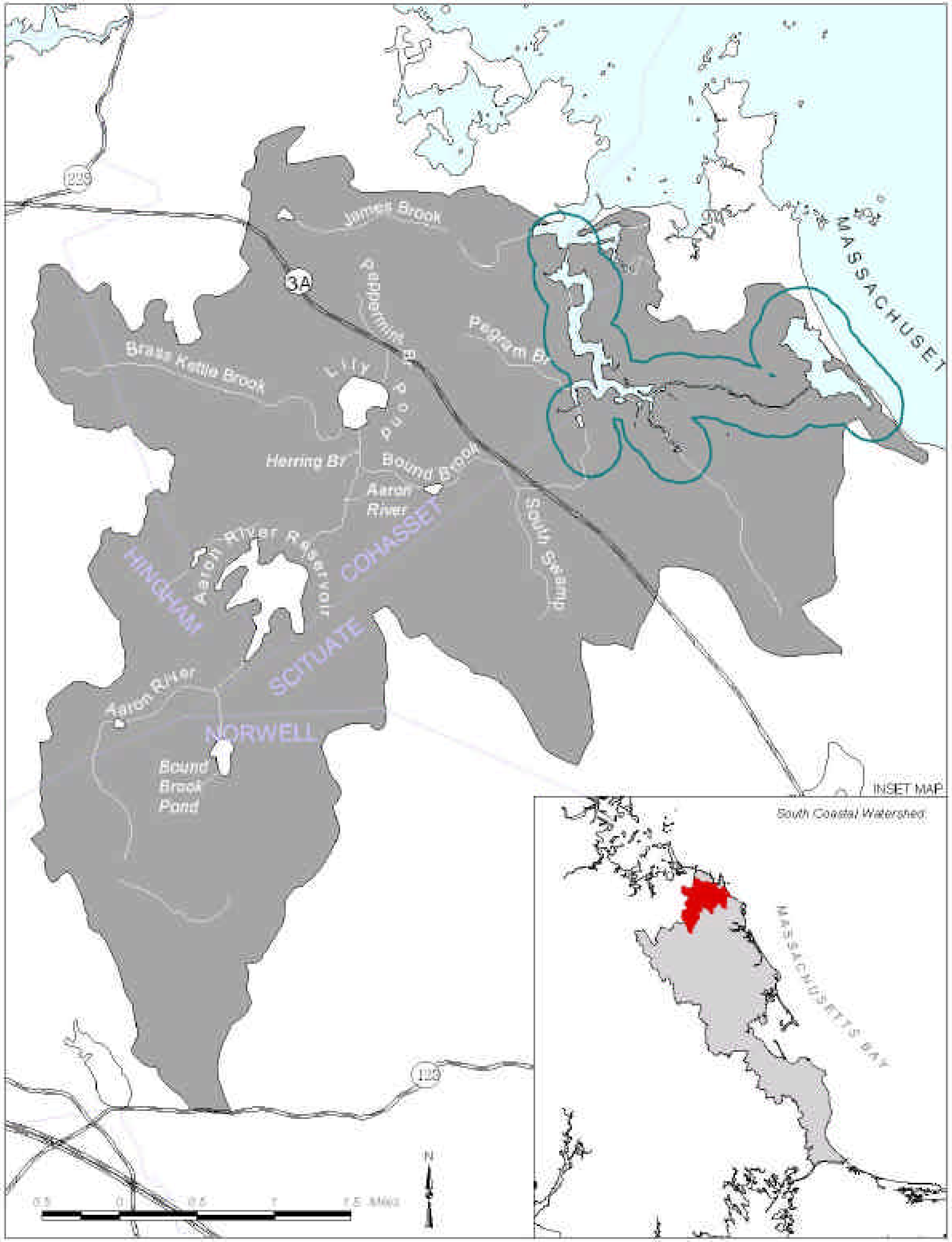

Figure 1-3. Gulf River Watershed (with South Coastal Watershed Displayed in Inset).

2. HISTORY

2.1 REGIONAL HISTORY

Cohasset and Scituate are both coastal suburban resort towns south of Boston on Massachusetts Bay. Cohasset is located on rocky coastal lowlands with numerous small bays and adjacent uplands. There are two large freshwater ponds located inland with large areas of bog and swamp. Scituate is similar in that it is located in coastal lowland with extensive wetlands. The town has experienced significant erosion in its southern coastal areas (MHC 1979b).

Scituate was incorporated in 1636. The original boundaries of the town were established in 1643 with the northwest boundary being the Plymouth-Massachusetts Colony line. Scituate has a network of suspected Native American trails in the town and numerous documented and suspected Native American sites, particularly in the area west of Musquashcut Pond and in the area south of Scituate Harbor. The area possessed attractive food sources including productive planting grounds, rich clamming areas, wild game, and productive fisheries (alewives, shad, mackerel, bass, and eels) close to shore. These food sources indicate a high potential for Native American settlement prior to the arrival of Europeans (MHC 1979b). The earliest European settlement took place in an area south of Scituate Harbor where Native American planting grounds were utilized. Early settlement tended to remain in coastal areas until the time of the King Phillips War when it spread along the North River Valley. Action during the King Phillips War inflicted considerable property damage on the town (MHC 1979b). A limited Native American population continued to exist in the area. Community expansion and development from the coast westward was facilitated by the town's diversified resource base.

Cohasset was originally used as haylands and pasture by the town of Hingham. When a settlement of sufficient magnitude developed, the town of Cohasset was incorporated in 1771 (Deane 1975; MHC 1979a; MHC 1979b). Cohasset, although located on the outside of regional routes, has well documented archaeological sites from the Woodland period along the shore and interior valleys (MHC 1979a). The trail system that ran through the town was part of a coastal system from Massachusetts Bay to North River and Plymouth. Good clamming, fishing, and decent farmland close to shore position the area as one likely to have been used by Native Americans. John Smith came to "Quonahassit" harbor in 1614. Permanent European settlement extended from the town of Hingham in the late 17th century. Over the decades, this settlement had included immigrants from Ireland, Portugal, and Italy (MHC 1979a).

2.2 LOCAL INDUSTRIES

During the colonial period, as early as 1643, shipyards were established along the North River in Scituate. Maritime activities, shipbuilding, and fishing began to gain prominence over agricultural efforts in Scituate's economic base. Saw and gristmills were built on brooks and Musquashcut Pond starting in the 1600s. In 1730 a tidal mill was built on the western shore of Scituate Harbor. Initially, the fishing industry focused on inland streams and rivers, but offshore fishing became increasingly prominent in the later part of the 17th century as a profusion of mills blocked fish stream routes. Transportation during the late 17th through the early 19th century was through a system of packet boats with regular runs to Boston starting as early as the mid-17th century. In the mid-19th century shipbuilding began to decline. This economic downturn resulted in a decline in town growth rate. Poor soil quality precluded a reasonable return to a purely agricultural economy. Small shoe shops and the mossing industry provided some employment during the late 19th century until the situation improved with the construction of the Cohasset and Duxbury Railroad.

The railroad opened easy communications and exchange with Boston. Convenient transportation instigated resort development of the Scituate coastline. Densely populated beach areas, with little or no public access to the water, characterized this development. Prior to resort development, settlement patterns were primarily linear along colonial roads. More recently, in the 20th century, the construction of the Southeast Expressway opened the town to suburbanization and has resulted in the conversion of a large proportion of the summer residences to year round occupancy (MHC 1979b).

Cohasset was, at first, a farming and grazing community. Dairies, orchards, tanneries, and lumbering were also pursued. Saw and gristmills were built starting after 1679 and an ironworks was erected in 1703. In the 18th century, however, economic development occurred primarily along the coastal shore. Cooperage and other maritime activities followed the start of ship building operations in 1708. Commercial fishing for mackerel and cod after 1730 and merchant voyages to the West Indies by 1750 strengthened the focus on a maritime economy. "Along with the schooner fleets which formed the backbone of the town's economy, there also were a number of larger sailing vessels owned or operated by Cohasset residents [that carried on mercantile trade throughout the world from Boston]" (Davenport & Osgood 1984). By 1800, a major corn mill was located at the mouth of the Gulf River. Small scale manufacturing (shoes and woodenware) as well as extensive production of salt in the saltworks along the coast took place in the mid 1800s. "Cohasset's peak years as a mackerel fishing port were reached in the middle of the nineteenth century" (Davenport & Osgood 1984). After 1885, fishing and the occupations that supported it (i.e. saltworks and cooperage) ceased in the area. In the 1820s, tourists began to arrive in Cohasset. There was substantial development of residential resort areas along the coast by the 20th century. Immigration and a diverse economy were important to the Cohasset economy after the collapse of the fishing industry. In the 1930s, the highway extended to Cohasset along historic interior routes. Currently, Cohasset is home to a large and consistently growing number of commuters, but there is little commercial development.

2.3 GULF RIVER

The following information on the Gulf River was extracted from John F. Hartshorne's "A History of the Gulf River," presented to the Gulf Association on May 29, 2002.

"Connyhassit" is the earliest name for what is now called the Gulf River. This region was important in the early days of settlement because of the abundant salt hay, cord wood, and ice. Salt hay provided a convenient source of nourishment for the settlers' cattle. It was harvested in the Gulf's salt marsh meadows by horse and wagon or by flat-bottomed boats called *gundalows*, which were poled along the shallow waters and tied-up at landing places along the river. The salt hay resource was so essential to the settlers that it influenced the political boundary that now divides Scituate and Cohasset down the middle of the harbor and the Gulf River. Cord wood was shipped in bargeloads from a landing at the mouth of Pegram Brook and floated to Boston. Ice was another commodity that was cut on the river and packed between layers of hay in ice houses.

There also is a legacy of industrial activity in the Gulf River and its tributaries. In 1691, a blacksmith from Hingham—Abraham Lincoln's father, Mordecai Lincoln—built several dams and grist mills along Bound Brook. One of the mills built at the head of Bound Brook operated until 1930 as a bog iron smelter and forge, a saw mill, and a tannery. In the late 1700s, Elisha Doane built a dam and grist mill at the mouth of the Gulf River as it enters Cohasset Cove. Limited remains of this mill are visible today.

Native American artifacts have been found along the shores of the Gulf and it is believed there once was an Indian village on the eastern shore. The village was linked to another in Scituate Harbor by a path that today constitutes part of the "Indian Trail," leading from Scituate's Gardner Road.

2.4 FLOOD HISTORY

Because of their coastal New England location, both Cohasset and Scituate are highly susceptible to coastal storms (e.g., tropical storms, hurricanes, and northeasters). During a coastal storm, wave action and localized reductions in atmospheric pressure can result in abnormally high sea levels, referred to as *storm surge*. The duration and severity of a storm surge is dependent on the size and track of the storm, proximity to the coastline, wind direction and fetch, and shape of the ocean floor. The storm that produces the most devastating surge is the coastal northeaster—large counterclockwise-circulating storms that travel southwest to northeast along the Atlantic Coast. They have less intense winds than a hurricane, but the storm itself travels more slowly and covers a larger area, resulting in a storm that can last several days. Northeasters are usually active long enough to impact at least one high tide, which leads to the most severe flooding conditions.

Flood events are reported in terms of their recurrence interval. Flood intervals of 10-, 50-, 100-, and 500- years have been selected as having special significance for flood management and flood insurance rates (FEMA 1986). These events have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded in a given year. These intervals represent a long-term average period between floods of a specific magnitude but this does not mean that two 50-year events, for example, could not occur in a shorter interval or even within the same year.

The national standard adopted by the Federal Emergency Management Agency (FEMA) for flood management is the one percent annual chance (100-year) flood. The 0.2 annual chance (500-year) flood indicates additional areas of flood risk in a community. Figure 2-1 illustrates the boundaries of the 100- and 500-year flood events in the vicinity of the Gulf River estuary as developed by FEMA. At the time of this study, FEMA was in the process of reassessing the flood potential and flood hazard areas for Scituate (Carlson 2002).

Table 2-1 illustrates the stillwater and base flood elevations for the Gulf River estuary and its tributaries. *Stillwater elevations* are a median measurement that reflect water surface elevations as a result of storm surge, but do not account for wave crest elevations. Stillwater elevations for a 100-year flood are used in combination with wave height, and wave runup analyses to determine *base flood elevation* and, ultimately, the location of flood hazard areas. Both stillwater and base elevation data are reported as the height sea level rises *above* normal sea level. These elevations were determined using computer models that stimulate storm surge.

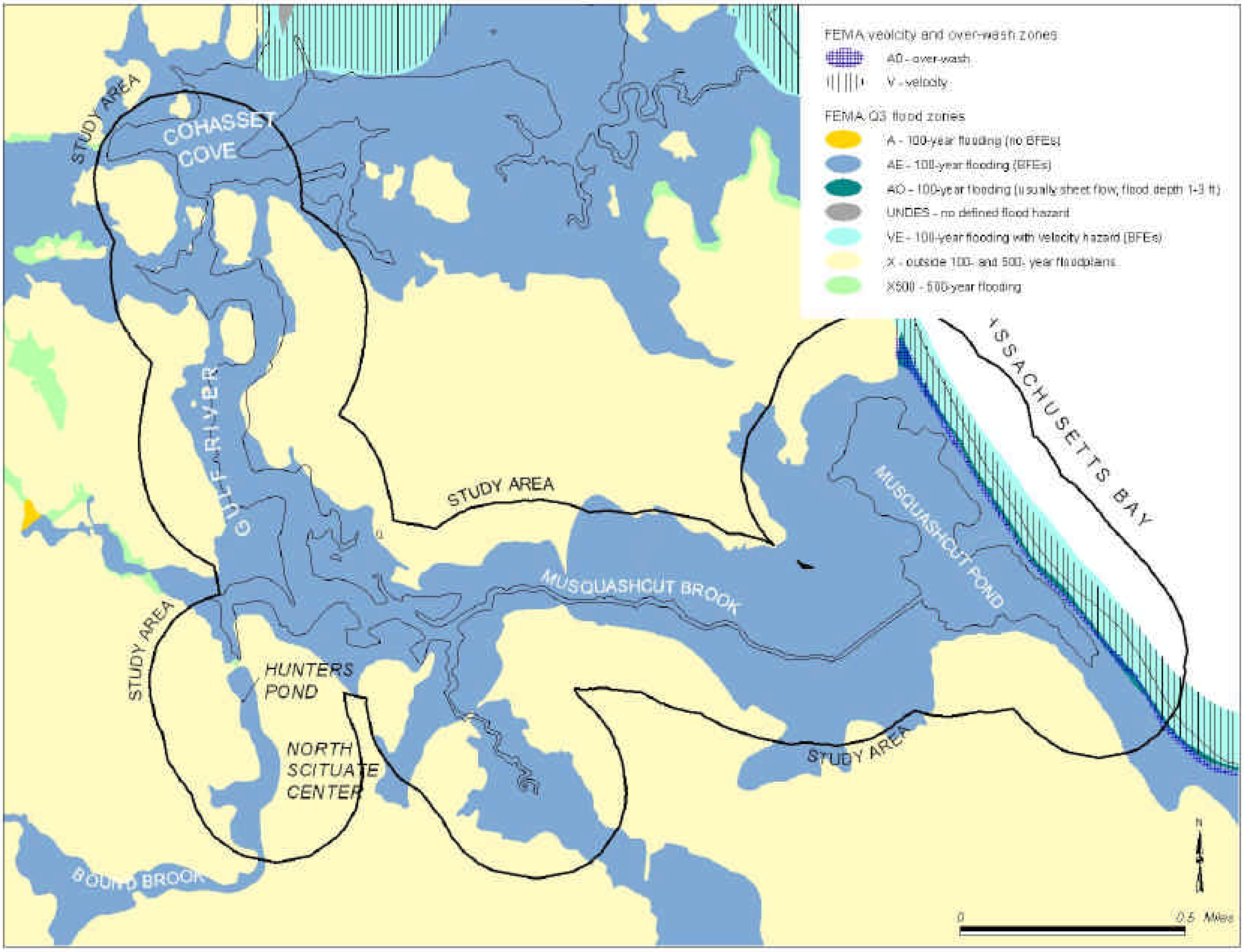

Figure 2-1. FEMA Boundaries For 100-year and 500-year Flood Events (Data Source: MassGIS)

Table 2-1. Stillwater and Base Flood Elevations in the Gulf River Estuary (elevations are in feet) (reproduced from (FEMA 1986)).

Flooding Source and Location	10-Year Elevation	50-Year Elevation	100-Year Elevation	500-Year Elevation	Base Flood Elevation
MUSQUASHCUT BROOK					
Mouth to Hollet Street	7.4	8.2	10.0	11.0	10-12
Hollet Street to The Gulf	7.4	8.2	8.4	9.2	8
MUSQUASHCUT POND					
Entire shoreline	7.4	8.2	11.5	12.4	12-13
BRANCH OF MUSQUASHCUT BROOK					
Mouth to Hollet Street	7.4	8.2	8.4	9.2	8
Hollet Street to approximately 2,000 feet upstream	7.8	8.5	8.8	9.5	9
THE GULF					
Mouth to Border Street	9.6	10.5	10.8	11.7	11
Border Street to Hunters Pond	7.4	8.1	8.4	9.2	8-10

The first major New England storm on record was the Great Coastal Hurricane of 1635, according to the National Oceanic and Atmospheric Administration's National Hurricane Center (NHC 1997) and the Northeast States Emergency Consortium (NESEC 2001). Since 1900, there have been 12 major land falling tropical cyclones and 41 systems that came close enough to impact southern New England. Land falling cyclones, four of which were category three hurricanes, occurred in 1916, 1938, 1944, 1954 (Carol), 1954 (Edna), 1955 (Diane), 1960 (Donna), 1976 (Belle), 1985 (Gloria), 1991 (Bob), 1996 (Bertha), 1999 (Floyd). Other severe storms were recorded in 1815, 1841, 1849, 1869, 1878, 1888, 1923, 1927, 1950 (Dog), 1962 (Daisy), 1972 (Agnes), 1978, 1991 (No Name), 1992, and 1996 (Lili).

The "benchmark of New England storms" (Mailhot 2000), the New England Hurricane of 1938, was marked by severe storm surge as high as 15 feet (Vallee 1999) and wind gusts in excess of 100 miles per hour (mph) along the coastline. Sustained winds of 121 mph were measured at Blue Hills Observatory in Milton, MA (Vallee 1999). According to the National Hurricane Center, the 1938 storm ranks 22nd on their list of most intense hurricanes nationwide (NHC 1997b). Hurricane Carol in 1954 had a storm surge comparable to the 1938 storm, resulted in approximately $2.7 million (in 1996 US dollars) in damage (NHC 1997a), and ranked 56th among most intense hurricanes (NHC 1997b). Hurricane Edna was even more intense, ranking 40th and following 11 days after Carol. In 1955, Hurricane Diane was less intense but resulted in greater damages (NHC 1997a). In 1960, Hurricane Donna, ranking 6th among intense hurricanes (NHC 1997b), resulted in significant damage in all areas of New England (Mailhot 2000). Hurricanes Donna and Carol are noted for producing strong gusting winds at 135 mph (NOAA 2002). Hurricane Daisy followed directly on the heels of a 1962 Northeaster and the combined storm surges resulted in significant flood damage in New England (Mailhot 2000; Vallee 2000).

The most severe winter storm to strike New England was the Blizzard of 1888, which deposited as much as 50 inches of snow. The Blizzard of 1978 was another severe winter storm that deposited almost 40 inches of snow (NESEC 2001). Hurricane Bob in 1991 set the record for total 24-hour precipitation (NOAA 2002). The No Name Halloween storm of 1991 produced little landside weather, but the storm surge and coastal damage was extensive (Mailhot 2000). In 1996, a "tropical connection" between Hurricane Lili and an upper-level system created rainfall amounts in excess of 10 inches in 24 hours in parts of Massachusetts (Banerji 1996).

For both Cohasset and Scituate, the last 100-year flooding events were in February 1978 and October 1996. In 1978, flood elevations in the vicinity of the Gulf River estuary ranged from 8 –13 feet above mean sea level (FEMA 1986). Heavy damage was experienced in the lowlands surrounding Cohasset Cove and most land in the Gulf River south of the Border Street bridge (FEMA 1986).

The loss of life; damage to property, town facilities, and utilities; and potential harm to ecosystem health are all important flood concerns. Scituate participates in a number of Federal Emergency Management Agency (FEMA) mitigation programs. Engineering techniques have been used to mitigate flood damage in the area in the past. The state also recommends a combination of the following measures to ensure safe and cost effective hazard mitigation (DEM 1999):

- Land use planning & regulation of development in hazard-prone areas, such as prohibiting new construction in a floodplain, along coastline, or in any other hazard prone area.
- Enforcement of building codes and environmental regulations.
- Public safety measures such as continual maintenance of roadways, culverts, and dams.
- Acquisition or relocation of properties, such as purchasing buildings located in a floodplain.
- Retrofitting of structures and design of new construction such as elevating a home or building.
- Coastal zone management, such as dune restoration and harbor safety measures.
- Comprehensive emergency planning, preparedness, and recovery.

3. HABITATS OF THE GULF RIVER ESTUARY

Major habitat features of the estuary are discussed below, including estuaries, tidal flats, salt marsh, barrier beaches, and vernal pools. Figure 3-1 shows the division of major habitats and Figure 3-2 provides a detailed illustration of these features.

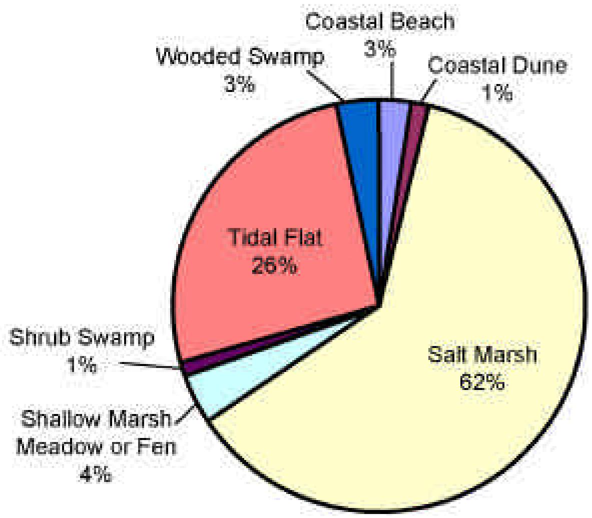

Figure 3-1. Percent Distribution of Wetlands Features in the Gulf River Estuary Study Area.

3.1 ESTUARIES

Regions along a coastline where fresh water rivers meet the ocean are called estuaries. Estuaries are the receiving waters for a variety of soils, detritus[2], and nutrients[3] carried downstream and deposited at the river's mouth. The combined forces of the ocean tides and river flows trap these materials, forming shallow shoals that, over time, provide a base for the formation of salt marshes and tidal flat communities. Because of the fresh water influence, estuaries also exhibit lower salinities capable of supporting both fresh and marine species. The unique combination of nutrients and habitat in estuaries provide a critical environment for many plants and animals.

Some organisms remain in estuaries throughout their lives, while others are dependent on this habitat only during a particular life stage. Two thirds of the important commercial finfish of Massachusetts, along with scores of other species, spawn in estuaries. Juveniles of many species utilize estuaries as a nursery while several anadromous species pass through estuaries on the way to spawning sites.

As estuaries receive all the runoff from the surrounding watershed, they are particularly sensitive to man-made influences. For example, pollution and physical alteration of a river can change nutrient loads, salinity and sedimentation rates and may disturb the balance of conditions on which a productive estuarine community relies.

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2 Excrement and other waste produced by all types of organisms, including their remains after death.

3 See page 33 for description of "nutrients."

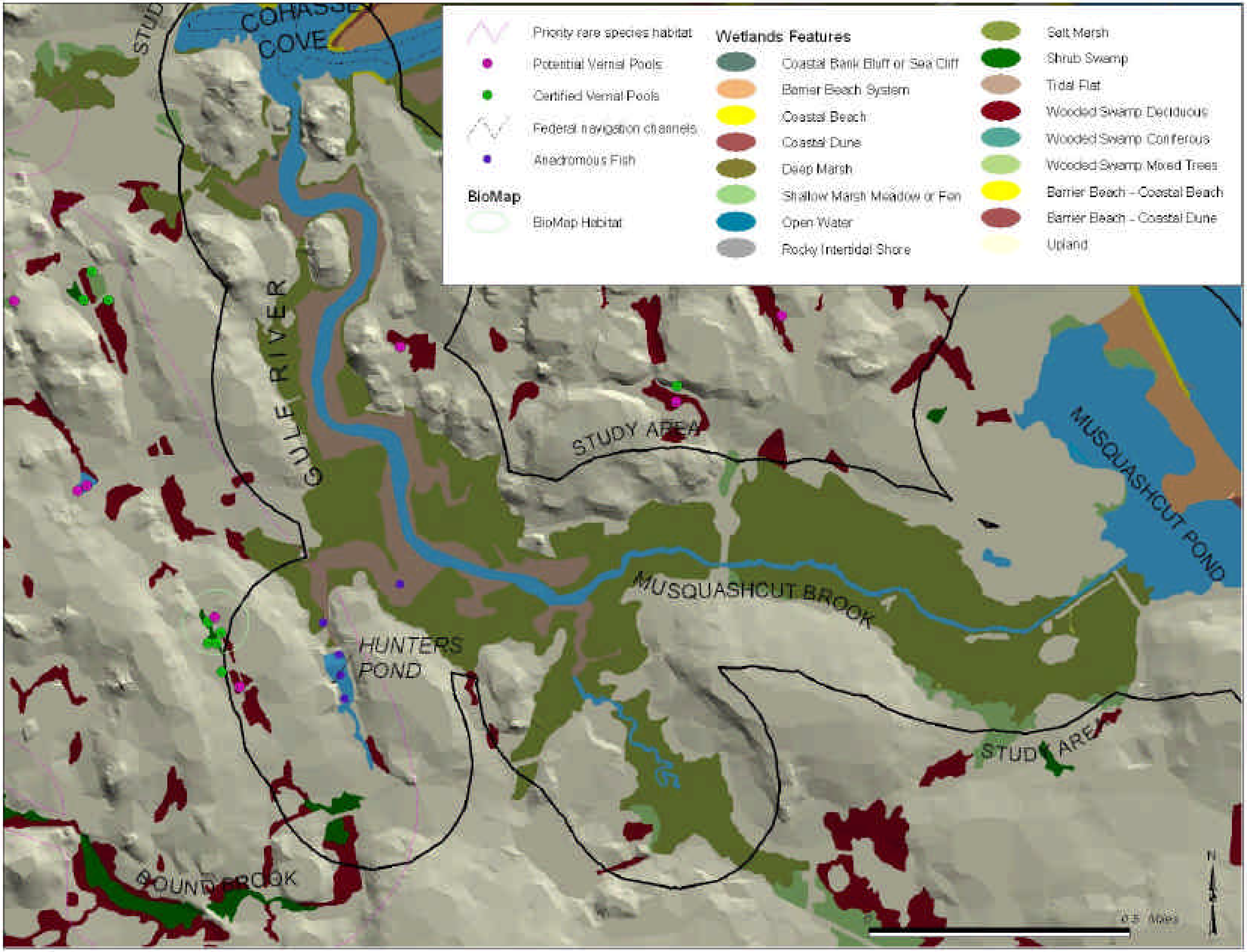

Figure 3-1. Wetland and Wildlife Habitat in Vicinity of Gulf River Estuary.

3.2 COASTAL BEACHES AND DUNES

There are 11 acres of beach and 6 acres of dunes within the Gulf River study area. Coastal beaches are comprised of loose sand and gravel that shift up, down and along the coast by wave and tidal forces. Because of their unconsolidated and unstable substrate, beaches are perhaps the least productive habitats in the coastal zone (Carlozzi *et al*. 1976). It is difficult for most plants to anchor to the sand and most organisms are not well adapted to the exposed and stressed beach environment. Since food-producing plants cannot survive in sand, the creatures that inhabit a beach are filter feeders or deposit feeders (e.g., flies and crabs) that survive on plant debris that originates elsewhere.

Sandpipers are common on beaches where they feed on sand shrimp, running ahead of each incoming wave. Gulls feed off clams and also human food waste. Terns and gulls use the foreshore beach environment to nest and raise their chicks.

Similar to beaches in composition and nature, dunes also are relatively unproductive habitats. Dunes are found inland from coastal beaches and are formed by wind erosion that blows beach sand inland where it encounters some sort of obstacle and this produces an accumulation of sand. Dunes play an important role in protecting upland communities from wave action during storms. While grass plays an important role in stabilizing sand dunes, only a few species of grass can withstand the constant wind and salt spray: American beach-grass (*Ammophilia* sp.), beach pea (*Lathyrus maritimus*), seaside goldenrod (*Salidago sempervirens)*, and dusty miller (*Senecio cineraria*) are common dune grasses (Carlozzi *et al*. 1976).

3.3 TIDAL FLATS

The shallow, sloping tidal flats common to estuaries support an enormous density of benthic[4] organisms. Tidal flats are also an important feeding ground for migratory shore birds. The species composition of tidal flat communities is determined by a combination of salinity, water and sediment quality and the patterns of water movement. Large plants, for example, cannot take hold in the sand-mud substrate of tidal flats. Algae and fungi, on the other hand, can tolerate surface exposure and proliferate on flats. Plankton and detritus carried by the tidal flow and river currents are also prevalent and are the main food source for the benthic communities on a tidal flat. Burrowing animals adapt to the daily stresses of the tide and extreme salinity and temperature changes by spending much of low tide buried in the exposed substrate. Invertebrates feed on detritus and organic material from the rivers and surrounding estuarine habitats, and provide a link between these communities and the commercial fish that in turn feed upon them at high tide.

There are approximately 56 acres of tidal flats, accounting for four percent of total wetlands acreage within the Gulf River estuary study area. Common species include mollusks and crabs for which more detailed information is presented in the next section on Biological Resources.

3.4 SALT MARSH

With 259 acres, the salt marsh in the Gulf River estuary accounts for 20 percent of the total wetlands habitat. Salt marshes develop in the intertidal areas where conditions enable silt and mud to accumulate. Healthy salt marshes provide the coastal environment with a multitude of biological and physical functions. Not only do they buffer the open water from stormwater runoff and pollution, they also protect coastal communities from flood and storm damage. Salt marshes are important nurseries for fish and habitats for birds, invertebrates, and wetland vegetation and are some of the most productive ecosystems in the world, contributing up to 10 tons of organic matter per acre to the surrounding marine and terrestrial communities (Carlozzi *et al*. 1976).

Salt marsh vegetation produces food from solar energy and nutrients, reduces extreme temperatures, transfers moisture to the air via evapotranspiration and adds organic material to the marsh soil. Due to the range of salinity and frequency of flooding, distinct zones of plant and animal life exist within salt marsh communities.

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[4] Pertains to the sea floor and the organisms that inhabit it.

The low marsh zone is flooded with every tide and is characterized by the predominance of the broad-leafed salt marsh cordgrass (*Spartina alteniflora*). The smaller salt meadow cordgrass (*Spartina patens*) is more common in the high marsh, where flooding occurs only during extreme high tides or storms (Carlozzi *et al*. 1976). Other common high marsh species include spike grass (*Distichilis spicata*) and salt marsh rush (*Juncus gerardii*). Mats of blue-green algae grow beneath the marsh grass and along the edges of the creeks and rivers all year round. These algae are nitrogen fixers and convert nitrogen from the air into a form that can be used by the marsh vegetation. In the fall and winter, bacteria, algae and organic matter associated with the decomposition of the thick grasses provide food for the bacteria, fungi, plankton and invertebrates living in the marsh. Tidal action flushes the phytoplankton and any excess nutrients through the estuarine and coastal waters, providing food for fish, mollusks, shrimp, and crabs.

Their ability to filter nutrients, sediment and heavy metals from coastal runoff and the overlying water column makes salt marshes particularly important in the human-coastal dynamic. However, as marshes are filled, mowed, or altered to make way for expanding development, this ability is reduced, leading to the degradation of the entire coastal environment. Additionally, nonindigenous species such as the common reed (*Phragmites australis)* pose a threat to the complex salt marsh ecosystem by replacing native vegetation and therefore altering the habitat for fish and wildlife.

Phragmites australis is found along the shores of the Gulf River and anecdotal evidence suggests that it has spread rapidly over the past five years, however no studies have been implemented to confirm this. *Phragmites* is a perennial grass common to the Atlantic state, Texas, and California. It is common in brackish or tidal marshes or along the upper edges of salt marshes (Tiner 1987), and is aggressive enough to dominate a plant community, particularly in areas that have been degraded or altered by human use. The life history of *Phragmites* remains unclear. Researchers continue to study where it fits into the flora of the Northeast region and New England, whether it is a native species that formerly was not invasive in nature, how it has spread, and how much its invasive nature can be attributed to recent manmade environmental changes (Driscoll 1999).

3.5 SHALLOW MARSH MEADOW

Approximately 16 acres of the Gulf River estuary are classified as shallow marsh meadow or fen. A shallow marsh or fen is an emergent wetland characterized by low land, a high water table, and seasonal flooding. Rushes such as *Juncus* sp. and members of the sedge family are plants commonly identified in New England shallow marshes (Tiner 1999).

3.6 WOODED AND SHRUB SWAMPS

Approximately 15 acres of the study area are wooded deciduous swamp and 4 acres are shrub swamp. These wetlands comprise all the fresh water wetlands within the study area. Swamps, like marshes, are often found near rivers or lakes, are often partially or intermittently covered with water, and have mineral soil that drains very slowly (Tiner 1999). But unlike marshes they have trees and bushes. The wooded swamps within the study area are deciduous.

3.7 SALT PONDS

Musquashcut Pond is a salt water pond that formed when a sand spit closed a narrow opening between the pond and the Atlantic Ocean. In the absence of tidal exchange with the Atlantic, a brackish condition was established when less saline water from the estuary became the source of water in the pond. Typical fish species that are found in salt ponds include menhaden, scup, tomcod, winter flounder, white perch and tautog.

Salt ponds are productive ecosystems and important habitats for water fowl, including ducks, gulls, terns, Canada geese, and mute swans. Because of their large surface area, low volume and limited water exchange, they are particularly vulnerable to human influences. Some of the problems with Musquashcut Pond are discussed in Section 9, Environmental Concerns and Pollution Sources.

3.8 BARRIER BEACH SYSTEM

A barrier beach separates Musquashcut Pond from the Atlantic Ocean. Barrier beaches provide for added protection against wind sheer and low-grade wave action. Because a barrier beach is composed of materials that are easily eroded and transported, the beach area and topography change considerably over time.

In addition, since barrier beaches have elevations barely above high tide level, they are also prone to wave overwash during stormy weather. In a washover, water from the Atlantic Ocean is driven across the barrier beach, leading to increased flooding particularly within the more confined area of Musquashcut Pond.

3.9 VERNAL POOLS

Vernal pools are small, temporary ponds created when a depression in the landscape fills with water during part of the year, usually early spring. Several rare plants, reptiles and amphibians thrive in the unique temporary aquatic habitats. Egg laying amphibians like the spotted salamander (*Ambystoma maculatum*), wood frog (*Rana sylvatica*) and spadefoot toads (*Scaphiopus holbrookii*) depend on vernal pools as spawning habitats. The advantages of breeding in a verbal pool are that food resources are abundant and predation from fish is low (EPA 2001). The disadvantages are that the length of time a vernal pool can hold water—the hydroperiod—varies from year to year, depending on certain environmental conditions such as area, depth, soil porosity, shading, and weather (Nedeau 2002). As a result, the suitability for breeding is unpredictable for the animals that depend on it to propagate their species. The vernal pools in Cohasset have a particularly short hydroperiod and contain fewer vernal pool species than is typical for Massachusetts (Cohasset Open Space Advisory Committee 2001).

Despite their important ecological functions, vernal pools are typically very small or invisible during the drier half of the year and particularly vulnerable to development. The National Heritage and Endangered Species Program (NHESP) have identified two potential vernal pools in the study area (see Figure 3-2). These vernal pools were identified by NHESP using aerial photos, but have not been verified by field tests. There are no certified vernal pools within the Gulf River study area.

3.10 PRIORITY RARE SPECIES HABITAT

The southwestern corner of the Gulf River estuary study area has been designated a priority rare species habitat by NHESP. Priority habitats were identified to inform the public about rare plant and animal species locations. Over time, some of these areas will be designated “significant habits,” which will afford additional protection to the land under the Massachusetts Endangered Species Act (M.G.L. c. 131A).

3.11 BIOMAP

With funding from the Massachusetts Executive Office of Environmental Affairs, the Natural Heritage Program developed BioMap to identify areas most in need of protection to protect native biodiversity. BioMap is an extension of NHESP, focusing on state-listed rare species and their natural communities. The goal of the program is to map areas that, if protected, will provide suitable habitats over the long term for rare species and other important natural communities.

4 GEOLOGY AND SOILS

4.1 GEOLOGY

Massachusetts is divided into a number of geologic belts and terranes that are separated from one another by major faults. The Gulf River watershed lies within the Avalon terrane, which is believed to have derived from the Gondwanan supercontinent, breaking away from Godwana about 490-550 million years ago (Skehan 2001). The Avalon terrane was originally a volcanic island chain near the present day south pole. Major geologic features of the Avalon terrane include: Dedham granite, Boston Basin, Milford granite, Sharon Upland, Narraganset Basin, and Fall River batholith (see Figure 4-1). The Avalon terrane is separated by the Clinton-Newbury fault to the north and the Nauset fault to the south.

Cohasset and Scituate are underlain by the Sharon Upland, which is bedrock composed mainly of granite, syenite, and gabbro that is over 1 billion years old. Granite contains large crystals visible to the naked eye and formed during the cooling of magma (molten rock). Syenite is a pale rock composed mostly of feldspar (a combination of calcium, sodium, potassium, and aluminum silicate) with very little or no quartz, (Skehan 2001). Gabbro also formed during the cooling of magma but it is darker and crystals are only visible with a magnifier.

The last North American ice age ended about 21,000 years ago when the Wisconsonian ice sheet began receeding to the north. During its retreat, this enormous glacier deposited substantial amounts of crushed rock debris and large volumes of water, forming glacial lakes in many regions. There are no glacial lakes in Cohasset or Scituate, but it is the action of the retreating ice sheet that created the region's rocky shoreline and tidal marsh depressions (Cohasset Open Space Advisory Committee 2001). Figure 4-2 illustrates the location of sand and gravel deposits in the Gulf River estuary study area. These data were compiled by the US Geological Survey and made available in digital format through MassGIS.

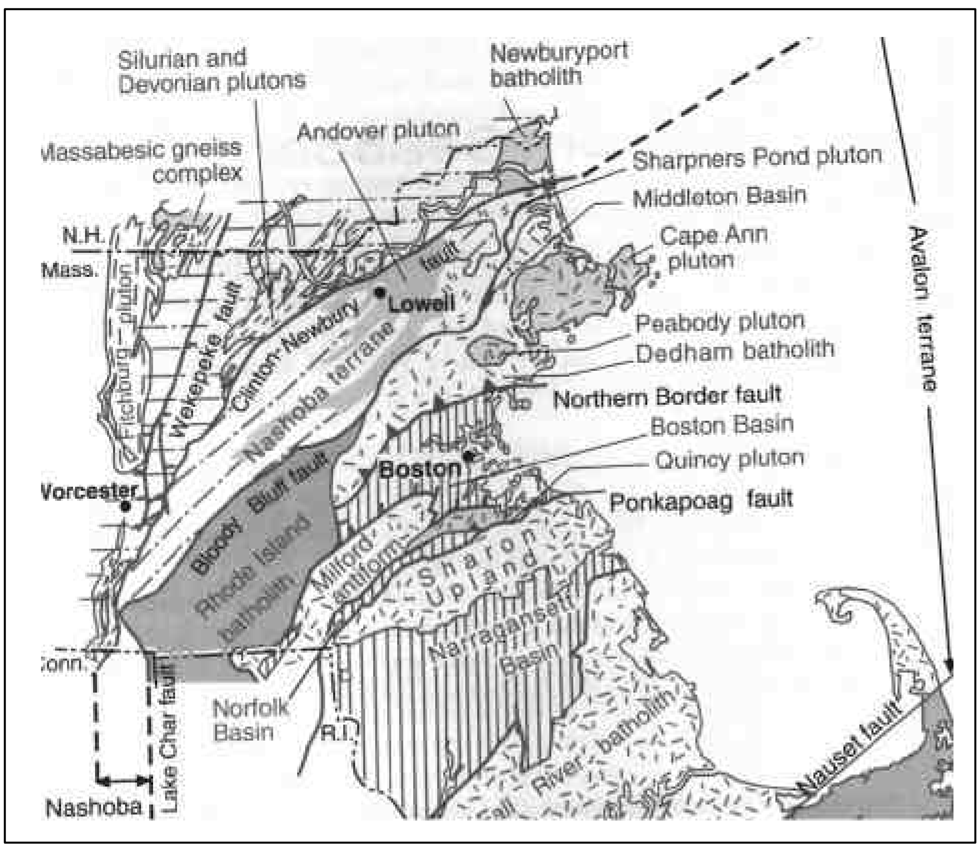

Figure 4-1. Major Geological Features in the Vicinity of the Gulf River Watershed, from Skehan (2001).

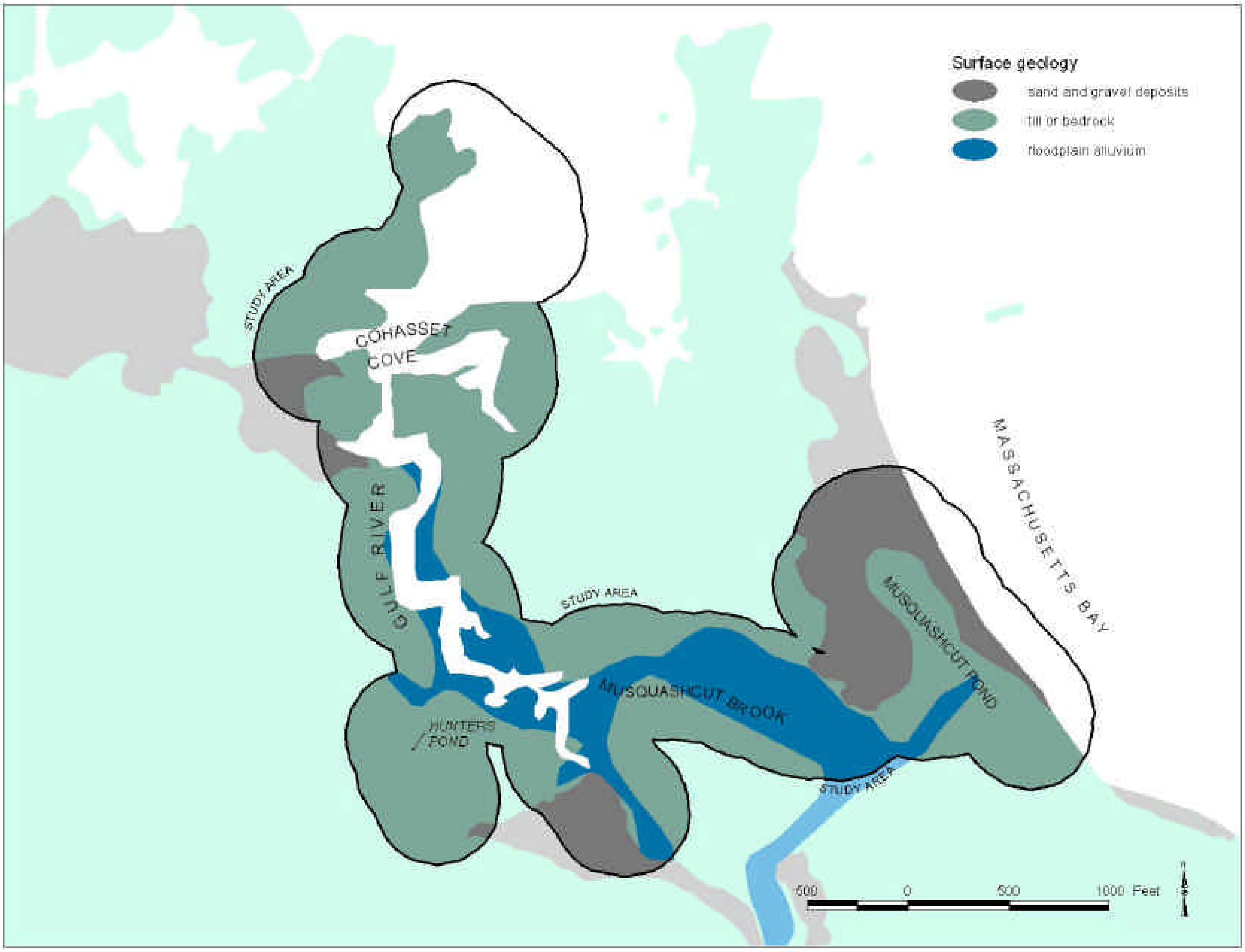

Figure 4-2. Surface Geology in Vicinity of Gulf River Estuary (data source: MassGIS).

4.2 SOILS

Soil survey data for Norfolk and Plymouth Counties are available from the US Department of Agriculture, Natural Resources Conservation Service (NRCS) (USDA 2002). Norfolk County was last surveyed in 1989 (USDA 1989) and Plymouth County in 1969 (USDA 1969). NRCS is currently resurveying Plymouth County and these data will be available in 2006 (USDA 2002). Soil surveys provide information important for identifying potential problem areas before construction and for determining any limitations of the land for particular uses, such as housing, septic systems, roads, agriculture, and recreation (Keller 1992).

Soils are classified using a hierarchal system similar to that used for plants and animals. The most specific, or lowest category, of soil classification is the *soil series*. Each soil series is differentiated based on a number of chemical and physical properties such as depth of water table (height of ground water), type of water table, permeability range, and hydrologic group (USDA 2002). There are roughly 15 different soil series identified in the Gulf River estuary study area: Brockton, Canton, Chatfield – Canton complex, Hinesburg, Ipswich, Merrimac, Newport, Norwell, Paxton, Pittstown, Saugatuck, Scituate, and Walpole. The most abundant of these series found in the area are described below.

In general, the soils in the vicinity of the Gulf River estuary represent a combination of well-drained and poorly drained soils with numerous rocky outcroppings. Because of either too slow or too rapid soil permeability and seasonally elevated ground water levels, the soils in the study area are not especially well suited for septic tank absorption fields without special planning, design, or maintenance.

Chatfield – rock outcrop – Canton complex. Complexes "consist of two or more kinds of soils in such an intricate pattern or so small in area that it was not practical or in some cases possible, to map them separately at the selected scale of mapping," (USDA 2002). This soil complex consists of moderately deep Chatfield soils and areas of bedrock outcrops with Canton soils on the slopes. It is foremost in the land area between the Border Street bridge and Musquashcut Pond (see Figure 4-3). Surface runoff is moderate and ground water pollution from septic systems is a potential hazard because of rapid permeability.

Hooksan series. Very deep, undulating and rolling, excessively drained soil, which formed in thick sandy eolian Holocene sediments adjoining beaches. Hooksan soils occur on vegetated sand dunes along the coast and can be found on the barrier beach that separates Musquashcut Pond from the Atlantic Ocean (see Figure 4-3).

Ipswich series. This soil series consists of very deep, poorly drained soils formed in thick organic deposits. Runoff is very slow. Most Ipswich soils are found in tidal marshes as they are along the edges of the Gulf River estuary (see Figure 4-3). They provide habitat for fish, shellfish, and birds and are good for growing saltgrass hay (USDA 2002), but are not suitable for development.

Merrimac series. Merrimac is characterized by very deep, excessively drained soils formed in glacial outwash. Runoff is slow to moderate and the soil is well suited for agriculture (USDA 2002). The soils quickly absorbs but does not adequately filter sewage effluent so ground water pollution from poorly designed septic systems is possible. Merrimac soils are found in the pocket of land between Musquashcut Pond and Musquashcut Brook on the northern side (see Figure 4-3).

Newport series. Newport consists of very deep, well-drained loamy soils formed in glacial till. Surface runoff is moderate to rapid. Newport soils are good for agriculture and residential-scale development (USDA 2002). Use of these soils for septic tank absorption fields can be problematic because permeability tends to restrict absorption of effluent. They are most prevalent in the area southwest of Musquashcut Brook (see Figure 4-3).

Paxton series. This soil series consists of very deep, well-drained loamy soils formed in subglacial till. Surface runoff is moderate to rapid. Paxton soils are good for agriculture and residential-scale development (USDA 2002) although permeability restricts the absorption of effluent. They are common to the northwest of Hunter's Pond and on the west side of the Gulf River (see Figure 4-3).

Rock outcrop – Hollis complex. This soil complex is characterized by primarily rock outcrop with small areas of Hollis soils, which have bedrock close below the surface. These areas are unsuited for most uses because of the underlying bedrock.

Table 4-1. Specific Soil Types Surveyed By NRCS in Gulf River Estuary Study Area.

Brockton extremely stony loam	Norwell extremely stony sandy loam
Canton fine sandy loam	Paxton fine sandy loam
Chatfield – rock outcrop – Canton complex	Pittstown silt loam
Hinesburg fine sandy loam	Pittstown very stony silt loam
Hooksan duneland	Saugatuck loamy sands
Ipswich mucky peat	Scarboro fine sandy loam
Merrimac fine sandy loam	Scituate very stony sandy loam
Merrimac sandy loam	Walpole sandy loam
Newport fine sandy loam	Walpole fine sandy loam

Figure 4-3. Major Soil Series in Vicinity of Gulf River Study Area.

5. BIOLOGICAL RESOURCES

5.1 ENDANGERED, THREATENED AND SPECIAL CONCERN SPECIES

The Natural Heritage and Endangered Species Program (NHESP) is part of the Massachusetts Natural Heritage Program and is administered by the Massachusetts Division of Fisheries Wildlife and Environmental Law Enforcement. "NHESP is responsible for the conservation and protection of hundreds of species that are not hunted, fished, trapped, or commercially harvested in the state." NHESP enforces the Massachusetts Endangered Species Act (M.G.L. c. 131A), prohibiting the taking of any rare plant or animal species listed as Endangered, Threatened, or of Special Concern. Although there are no rare species identified in the Gulf River estuary study area (see letter in Appendix A), NHESP has identified two threatened and six special concern species in Cohasset and Scituate within the past 25 years.

The threatened species include the piping plover (*Charadrius melodus*), a shorebird, and swamp dock (*Rumex verticillatus*), a plant. Threatened species are defined by the NHESP as "native species which are likely to become endangered in the forseeable future, or which are declining or rare as determined by biological research and inventory."

Special concern species include the spotted turtle (*Clemmys guttata*), mystic valley amphipod (*Crangonyx aberrans*), least tern (*Sterna antillarum*), seabeach needlegrass (*Aristida tuberculosa*), and American sea-blite (*Suaeda calceoliformis*), which is a plant. Special concern species are defined by NHESP as: "Native species which have been documented by biological research or inventory to have suffered a decline that could threaten the species if allowed to continue unchecked, or which occur in such small numbers or with such restricted distribution or specialized habitat that they could easily become threatened in Massachusetts." Fact sheets for each of these species can be found in Appendix A.

5.2 BIRDS

A wide array of birds are attracted to large salt marshes as they travel between northern breeding habitat and southern over-wintering areas. The Gulf River estuary is an excellent example of such habitat, with an extensive salt marsh system supporting over 100 resident and migratory bird species. This diverse population of birds takes advantage of the unique combination of forest, grassland and estuarine habitat available in and around the Gulf River. Crustaceans, mollusks, salt marsh grasses, and aquatic vegetation provide a constant food source for these indigenous and migrant shorebirds and waterfowl. Table 5-1 provides a comprehensive list of birds documented in the area by the Massachusetts Audubon Society's South Shore Regional Office (Clapp 2002). Within this list, a number of rare species stand out, including the Pied-billed Grebe, Purple Finch, and Evening Grosbeak. Although Audubon records indicate the Pied-billed Grebe has been observed, it has not been identified in the Gulf River estuary study area (see letter in Appendix A).

At the request of concerned golfers, in March 2002 two osprey perches were raised on the Hatherly Golf Course near the 6th tee and along the 16th fairway (Caughey 2002). The osprey perches were built and funded by the Hatherly Golf Course with design specifications provided by the Massachusetts Audubon Society. Hatherly Golf Course also has placed many upland bird boxes in conjunction with the Audubon Society and plans to place more in the 2003 season.

Table 5-1. List of Birds Identified in Vicinity of Gulf River Estuary.

American Black Duck	Eastern Bluebird	Palm Warbler
American Bittern	Eastern Kingbird	Pied-billed Grebe
American Crow	Eastern Meadowlark	Pine Siskin
American Goldfinch	Eastern Phoebe	Pine Warbler
American Kestrel	Eastern Screech-Owl	Prairie Warbler
American Pipit	Eastern Towhee	Purple Finch
American Redstart	Eastern Wood-Pewee	Purple Sandpiper
American Robin	Evening Grosbeak	Red-bellied Woodpecker
American Tree Sparrow	European Starling	Red-breasted Merganser
American Woodcock	Field Sparrow	Red-breasted Nutchatch
Baltimore Oriole	Fish Crow	Red-eyed Vireo
Bank Swallow	Fox Sparrow	Red-necked Grebe
Barn Swallow	Golden-crowned Kinglet	Red-shouldered Hawk
Bay-breasted Warbler	Gray Catbird	Red-tailed Hawk
Belted Kingfisher	Great Black-billed Gull	Red-throated Loon
Black Guillemot	Great Blue Heron	Red-winged Blackbird
Black Scoter	Great Cormorant	Ring-billed Gull
Black-and-white Warbler	Great Crested Flycatcher	Rock Dove
Black-bellied Plover	Great Egret	Rose-breasted Grosbeak
Black-billed Cukoo	Greater Yellowlegs	Ruby-crowned Kinglet
Black-capped Chickadee	Green Heron	Ruby-throated Hummingbird
Black-crowned Night Heron	Great Horned Owl	Ruddy Turnstone
Black-throated Blue Warbler	Hairy Woodpecker	Saltmarsh Sharp-tailed Sparrow
Black-throated Green Warbler	Harlequin Duck	Sanderling
Blackburnian Warbler	Hermit Thrush	Savannah Sparrow
Blackpoll Warbler	Herring Gull	Scarlet Tanager
Blue-gray Gnatcatcher	Horned Grebe	Semipalmated Plover
Blue-headed Vireo	House Finch	Semipalmated Sandpiper
Blue Jay	House Sparrow	Sharp-shinned Hawk
Blue-winged Warbler	House Wren	Short-billed Dowitcher
Bobolink	Indigo Bunting	Snow Bunting
Bonaparte's Gull	Killdeer	Snowy Egret
Brant	Laughing Gull	Song Sparrow
Brown Creeper	Lapland Longspur	Sora
Brown-headed Cowbird	Least Flycatcher	Spotted Sandpiper
Brown Thrasher	Least Tern	Surf Scoter
Bufflehead	Lesser Yellowlegs	Swainson's Thrush
Canada Goose	Lincoln's Sparrow	Swamp Sparrow
Canada Warbler	Little Blue Heron	Tennessee Warbler
Cape May Warbler	Long-tailed Duck	Tree Swallow
Carolina Wren	Magnolia Warbler	Tufted Titmouse
Cedar Waxwing	Mallard	Turkey Vulture
Chestnut-sided Warbler	Marsh Wren	Veery
Chimney Swift	Mourning Dove	Virginia Rail
Chipping Sparrow	Mute Swan	White-breasted Nuthatch
Common Elder	Nashville Warbler	White-crowned Sparrow
Common Goldeneye	No. Rough-winged Swallow	White-throated Sparrow
Common Grackle	Northern Cardinal	White-winged Scoter
Common Loon	Northern Flicker	Wilson's Warbler
Common Snipe	Northern Harrier	Winter Wren
Common Tern	Northern Mockingbird	Wood Duck
Common Yellowthroat	Northern Parula	Wood Thrush
Cooper's Hawk	Northern Waterthrush	Yellow Warbler
Dark-eyed Junco	Orange-crowned Warbler	Yellow-billed Cuckoo
Double-crested Cormorant	Orchard Oriole	Yellow-rumped Warbler
Downy Woodpecker	Osprey	
Dunlin	Ovenbird	

5.3 FINFISH

There are several important species of anadromous fish that travel the Gulf River estuary and its tributaries at certain times of the year to spawn (Figure 3-1). River herring such as alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) migrate upstream at the end of April or early May. The herring pass through the estuary and ascend a weir pool fishway to spawn in Hunter Pond in May or early June. Hatching is temperature dependent with gestation typically ranging from 3 to 10 days. Adult herring will leave the pond immediately after spawning but juvenile herring will usually spend their first few months in fresh water, returning to the ocean in late July through November when they have reached a length of two to four inches (Fiske *et al*. 1966).

Rainbow smelt (*Osmerus mordax*) runs have also been observed in Bound Brook (Chase 2002). In 1993 and 1994, the Massachusetts Division of Marine Fisheries (DMF) monitored Bound Brook and found spawning smelt during both years. The brook was again surveyed in 2000 and a viable population of smelt was reconfirmed (see letter in Appendix B). Smelt spawn in Bound Brook between March and May. Hatching of the smelt fry is temperature dependent but usually takes between 7 and 14 days. Adults will return to the ocean immediately after spawning and the juvenile smelt also move out of the brook after hatching, following along with the fresh water flow.

At the time of this investigation, it was reported that suitable flow of water through the weir pool at Hunters Pond is interrupted by heavy spring flow, which inundates the steps and makes it extremely difficult for the anadromous fish to pass (Brady 2002a). DMF suggested that the weir could be improved by constructing a wall on top of the dam to divert water away from the fishway, or by reconstructing the weir so that the ladder runs vertical to the dam instead of parallel to it (Brady 2002a).

A 1937 study of Musquashcut Pond noted the presence of sticklebacks, mummichogs, and silversides in the pond (Wells 1990). The Cohasset Open Space and Recreation Plan (2001) identify several recreational species caught in the area, including mackerel, bluefish, and striped bass. Striped bass are found especially in the Gulf River estuary. The Massachusetts Division of Marine Fisheries (DMF) has not conducted any directed sampling of fish species in the Gulf River. However, DMF suggested that species identified in the nearby North River would provide a good generalization of the types of finfish common to the Gulf (Brady 2002a; Hurley 2002). From 1964 to 1965, DMF conducted extensive sampling of fish in the North River (Table 5-2).

Table 5-2. Finfish Taken from the North River Area Typical of the Gulf River Estuary (Fiske *et al*. 1966).

Alewife	Cunner	Pollock
American Eel	Fourspine Stickleback	Pumpkinseed
American Sand Lance	Golden Shiner	Rock Gunnel
American Shad	Grubby	Sea Raven
American Smelt	Haddock	Sea Lamprey
Atlantic Cod	Johnny Darter	Striped Bass
Atlantic Silverside	Largemouth Bass	Threespine Stickleback
Atlantic Tomcod	Little Skate	Twospine Stickleback
Barndoor Skate	Longhorn Sculpin	White Hake
Black Crappie	Lumpfish	White Sucker
Bluegill	Mummichog	Windowpane
Brook Trout	Ninespine Stickleback	Winter Flounder
Brown Bullhead	Northern Pipefish	Winter Skate
Brown Trout	Ocean Pout	Yellowtail Flounder
Chain Pickerel	Ocean Sunfish	

5.4 SHELLFISH

Under direction of the National Shellfish Sanitation Program, the Massachusetts Division of Marine Fisheries (DMF) monitors and regulates shellfish beds. The Sanitation Program is a voluntary program designed to prevent human illness associated with the consumption of fresh and fresh-frozen shellfish. Through Sanitary Surveys (completed at least once every 12 years) and more regular annual and triennial evaluations, DMF conducts routine bacteriological testing to determine whether a bed should be closed, open, or restricted in some way to shellfishing.

Clusters of blue mussels (*Mytilus edilus*), as well as razor clams (*Ensis directus)*, quahogs (*Mercenaria mercenaria*) and the occasional soft shell clam (*Mya arenaria*) can be found along the shoreline, in the rocky intertidal, and in the shallow waters of the Gulf River. The flats and shellfish beds within the estuary—identified as MB-10 by DMF—have been closed permanently to both recreational and commercial shellfishing since 1994 when DMF became the lead agency responsible for administering the National Shellfish Sanitation Program (see Figure 5-1) (Churchill 2002). It is unknown whether the Gulf River was ever open to shellfishing prior to 1994. While not viable for human consumption, shellfish in the Gulf River provide an important source of food for local bird populations.

While not within the Gulf River study area, a portion of shellfish bed MB-10 that extends along the Scituate coastline is approved for recreational shellfishing. Landings data from DMF (see Table 5-3) and license data indicate that soft-shell clams are an important industry in the area.

Table 5-3. Landings of softshell clams, Town of Scituate

Year	Landings (bushels)
1996	750
1997	900
1998	450
1999	28
2000	0 (beds were closed in 2000)
2001	48

Table 5-4. Recreational shellfish licenses issued in Scituate

Year	Residents	Seniors	Non-residents
1995	228	93	67
1996	271	127	62
1997	279	102	77
1998	169	77	36
1999	157	35	96
2000	0	0	0
2001	63 (all grouped together)		

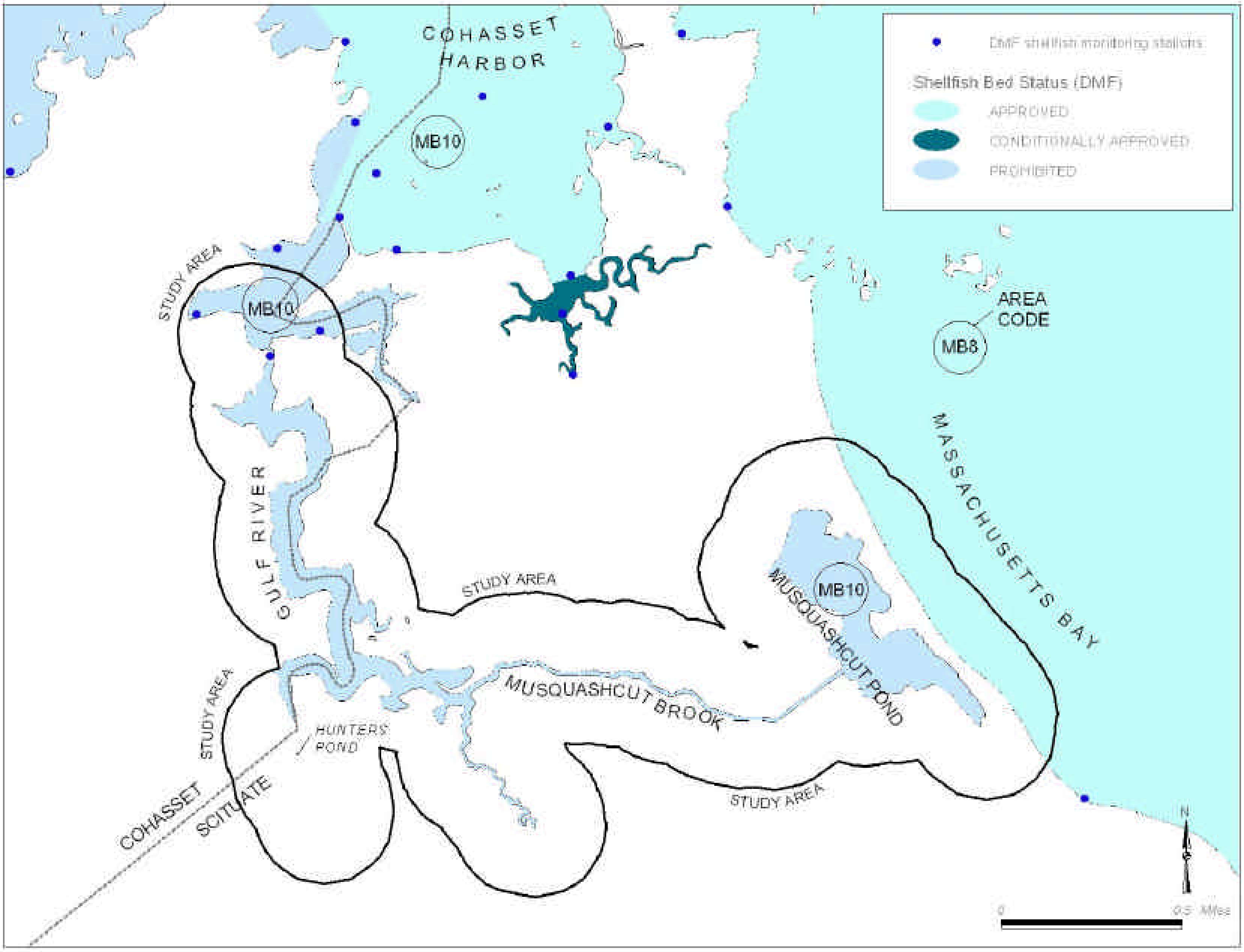

Figure 5-1. Status of Shellfish Beds in Vicinity of Gulf River Estuary (Data Source: MassGIS)

5.5 OTHER WILDLIFE

When compared with other towns in the area, Cohasset is heavily forested. Within the Gulf River watershed, Wompatuck State Park provides habitat for many species of mammals, reptiles, amphibians, and birds (Cohasset Open Space Advisory Committee 2001). Acres of contiguous woodlands, an increasingly rare occurrence in the area, contain interior forest species like box turtle (a species of "special concern"). Scrub habitat is present for Eastern cottontail rabbit, coyotes, and other species that are finding less of this type of land in which to reside. Cohasset's red maple swamps (Great Swamp) provide living space for species such as the star nosed mole and wood frog. In addition, these areas have a number of shallow ponds and vernal pools that provide habitat for frog, salamander, turtle, and invertebrate species. Cohasset has extensive forested areas along streams and rivers that form wildlife corridors. The most important of these is the Aaron River/Brass Kettle Brook/Bound Brook system, and there are also important riparian wildlife corridors in woodlands along the Gulf River estuary and Rattlesnake Run.

When compared with Cohasset, Scituate has a larger variety of wooded areas, abandoned pasture, and salt marshes. In Scituate, small mammal populations including woodchucks, rabbits, red fox, gray squirrels, skunks, opossum, and chipmunks are abundant. Raccoons were plentiful until decimated by a recent epidemic of distemper. Muskrats are common in the wetlands adjoining Satuit Brook and in South Swamp and other marshy areas of the West End. As has been observed throughout the region, deer have become noticeably more common in the past few years. Lastly, sightings of coyotes and wild turkey have been reported more frequently in recent years.

6. WATER QUALITY

Watersheds are defined by the natural path water follows as it flows from smaller to larger water bodies. For this reason, watersheds present the most logical scale at which to study water quality in order to gain a more complete understanding of overall conditions in an area and the stressors that affect those conditions. The Gulf River watershed is illustrated in Figures 1-3 and 6-1 and will be used as the basis for the discussions that follow.

6.1 STATE AND FEDERAL WATER QUALITY STANDARDS

The fresh and marine waters in the Gulf River watershed are classified according to the Massachusetts Surface Water Quality Standards (314 CMR 4.00). The Gulf River is designated Class SB and Lily Pond and the Aaron River Reservoir and their tributaries Class A. Class SB waters are considered suitable for aquatic life and wildlife, as well as for primary and secondary recreation. Class A waters are designated as a source of public water supply. They are also suitable habitat for aquatic life and wildlife and are suitable for recreation to the extent that these uses are compatible with its use as a water supply. Any actions that would prevent the uses of these waters are prohibited. Class A waters are also protected as *Outstanding Resource Waters* (ORWs), which "constitute an outstanding resource as determined by their outstanding socio-economic, recreational, ecological and/or aesthetic values," (314 CMR 4.04 (3)). Within ORWs, most existing, new, or increased discharges are prohibited. Water quality criteria for Class SB and A waters are listed in the table below. Included in this data are the criteria for Class SA waters, which is the designation for Cohasset Harbor where Cohasset's waste water treatment facility discharges.

More practical definitions of the classes of marine waters have been developed by the Buzzards Bay National Estuary Program, who propose that the following goals are met for each class (Costa 2000):

> *ORW: A large portion of eelgrass, shellfish, and benthic invertebrate habitat remain in a near natural productive state.*
>
> *SA: A majority of eelgrass, shellfish, finfish, and benthic invertebrate habitat remain in a near natural productive state.*
>
> *SB: Large losses of eelgrass, shellfish, finfish, and benthic invertebrate habitat may occur, but critical or catastrophic losses (complete loss of habitat, large accumulations of nuisance algae, chronic hypoxia or anoxia) are prevented.*

Table 6-1. Water Quality Criteria for Class SB, Class A, and Class SA Waters (314 CMR 4.00).

Parameter	Class SB Standard	Class A Standard	Class SA Standard
Dissolved Oxygen	Not less than 5.0 mg/l (unless background conditions are lower)	Not less than 6 mg/l) (unless background conditions are lower)	Not less than 6.0 mg/l (unless background conditions are lower)
Temperature	Not more than 85°F (29.4°C) or a daily maximum of 80°F (26.7°C)	Cold water fisheries: not above 68°F (20°C) Warm water fisheries: not above 83°F (28.4°C)	Not more than 85°F (29.4°C) or a daily maximum of 80°F (26.7°C)
pH	In the range of 6.5 – 8.5	In the range 6.5 – 8.3	In the range of 6.5 – 8.5
Fecal Coliform	Restricted shellfishing	Not to exceed mean of	Open shellfishing

Parameter	Class SB Standard	Class A Standard	Class SA Standard
	allowed: Not to exceed mean MPN[5] of 88 col/100 ml No shellfishing: Not to exceed mean MPN of 200 col/100 ml, and no more than 10% samples exceed 400 col/100 ml.	20 col/100 ml. No more than 10% samples exceed 100 col/100 ml.	allowed: Not to exceed mean MPN of 14 col/100 ml No shellfishing: Not to exceed mean MPN of 200 col/100 ml, and no more than 10% samples exceed 400 col/100 ml.
Solids	Free from floating, suspended, and settle-able solids that impair use or aesthetically degrade or impair water.	Free from floating, suspended, and settleable solids that impair use or aesthetically degrade or impair water.	Free from floating, suspended, and settle able solids that impair use or aesthetically degrade or impair water.
Color and Turbidity	Free from color and turbidity in concentrations that aesthetically degrade or impair any use.	Free from color and turbidity concentrations that aesthetically degrade or impair any use.	Free from color and turbidity concentrations that aesthetically degrade or impair any use.
Oil and Grease	Free from oil, grease, and petrochemicals.	Free from oil, grease, petrochemicals, and volatile organic or synthetic pollutants.	Free from oil, grease, and petrochemicals.
Taste and Odor	None that aesthetically degrade or impair use or impart undesirable color or taste to edible portions of aquatic life.	None other than natural origin.	None other than natural origin.

The Commonwealth of Massachusetts recently amended the bathing beach regulations, 105 CMR 445.000: Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII). These regulations were amended to comply with the beaches bill, which was signed into law in August 2000, M.G.L. Ch. 111, Sec. 5S. All public and semi-public beaches are required to be tested by the Board of Health or authorized representative (beaches operated by the state are tested by the Massachusetts Department of Public Health). Based on EPA recommendations, the amended regulations apply different indicator organisms and standards than the previous regulations.

[5] MPN, most probable number, is one of two techniques used to measure the presence of fecal coliform in water. It is also sometimes called the multiple fermentation tube technique. Bacteria counts are obtained by statistical approximation.

Table 6-2. Summary of Standards for Bacteria Indicator Species.

Activity	Indicator Organism	Marine Water	Fresh Water
RECREATION	*Enterococci*	Geometric mean of the most recent five (5) Enterococci levels within the same bathing season cannot exceed 35 colony forming units (CFU) per 100 ml. No single sample can exceed 104 CFU/100 ml.	Geometric mean of the most recent five (5) Enterococci samples within the same bathing season cannot exceed 33 CFU/100 ml. No single sample can exceed 61 CFU/100 ml.
	Escherichia coli	N/A	Geometric mean of the most recent five (5) E. coli samples within the same bathing season cannot exceed 126 CFU/100 ml. No single sample can exceed 235 CFU/100 ml.
		Class SB Water	Class A Water
SHELLFISHING	*Fecal coliform*	Restricted shellfishing allowed: Not to exceed mean MPN of 88 col/100 ml. No more then 10% samples exceed MON 260 col/100 ml. No shellfishing: Not to exceed mean MPN of 200 col/100 ml. No more than 10% samples exceed 400 colonies/100 ml.	N/A

In the amended regulations, fecal coliform (the collective name for organisms that inhabit the intestinal tract of warm-blooded animals) was replaced as the preferred indicator of pathogens because certain non-fecal coliforms present in soil and on the surface of plants cannot be distinguished from fecal coliforms by the tests commonly used. Therefore, the presence of fecal coliforms indicates contamination that could—but may not—involve serious pathogens. *E. coli* (a specific species of fecal coliform), on the other hand, is only endemic to feces and thus is a better and more consistent indicator upon which to establish standards.

The other bacterial indicator, *Enterococcus*, is a member of the fecal streptococcus group. *Enterococcus* also is believed to be a better indicator than fecal coliform and the best indicator for gastrointestinal disease. It is a good species for assessing reservoir quality, sewage-contaminated water supplies, and chlorinated water that is high in organics. *Enterococcus* is also considered the best indicator for monitoring recreational areas, especially in marine waters where *E. coli* do not survive well. Because *Enterococci* persist longer in the environment, however, they are not useful for pinpointing a pollution source since they can be detected at a distance from their point of origin (Bartram & Pedley 1996).

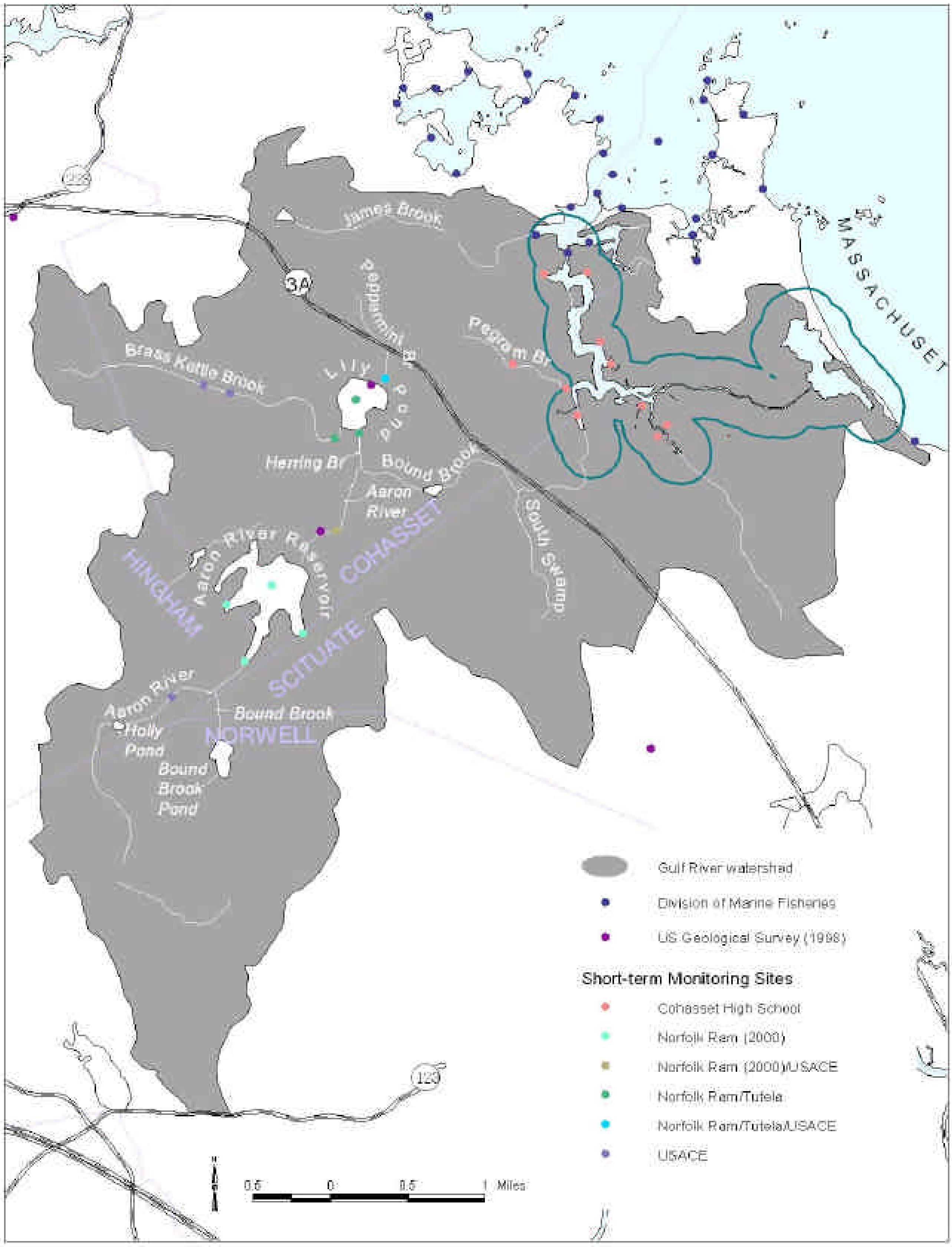

Figure 6-1. Location of Known Water Quality Monitoring Sites in Gulf River Watershed (Data Source: MassGIS, Norfolk Ram (2002), USACE (1999)).

6.2 IMPAIRED WATERS

Provisions of the federal Clean Water Act (CWA) require states to establish a program to monitor and assess the quality of its surface and ground waters and report on its findings. Section 305(b) of the federal Clean Water Act (CWA) requires each state to submit a *Summary of Water Quality Report* to the US Environmental Protection Agency (EPA) every two years (in Massachusetts this function is carried out by the Department of Environmental Protection (DEP)). "The 305(b) report represents the status of water resources with respect to their capacity to support designated uses as defined in each of the states' surface water quality standards" (EOEA & DEP 2002). In addition, DEP is required under Section 303(d) of CWA to prepare a *List of Impaired Waters* every two years, containing surface waters not expected to meet state water quality standards, even after implementation of technology-based controls for point and nonpoint sources of pollution. DEP uses guidance provided by EPA and policies established by DEP's Division of Watershed Management in preparing these lists. For each 303(d) impaired water body, DEP is required to calculate the maximum amount of pollutant that the water can receive without violating water quality standards. This total maximum daily load (TMDL) accounts for point and nonpoint sources, as well as background levels. In summary, "the 303(d) List identifies and prioritizes waters in need of further clean-up and the TMDL process provides the mechanism for allocating allowable pollutant loads" (EOEA & DEP 2002).

Massachusetts 303(d) lists were developed in 1992, 1994, 1996, and 1998. EPA made it optional for states to prepare a 303(d) list in 2000, and Massachusetts opted to focus its resources on TMDL efforts so no list was prepared (EOEA & DEP 2002). A draft *Integrated List of Waters* was released in October 2002, introducing a new format that combines elements of both 305(b) and 303(d) reporting. This format allowed all assessed waters to be presented in a single multi-part list broken into five categories: (1) unimpaired and not threatened for all designated uses, (2) unimpaired for some uses and not assessed for others, (3) insufficient information to make assessment for any uses, (4) impaired or threatened for one or more uses but not requiring the calculation of TMDL, and (5) impaired or threatened for one or more uses and requiring a TMDL. Waters listed in Category 5 constitute the 303(d) list, which must be reviewed and approved by EPA. The other four categories are submitted as part of section 305(b) requirements, replacing the old format.

Within the Gulf River watershed, Musquashcut Pond is Category 5 (former 303(d) list), and requires the state develop a TMDL for noxious aquatic plants. In addition, the Aaron River Reservoir is Category 5 as a result of site-specific mercury advisories issued by the Massachusetts Department of Public Health. According to the 2002 *Integrated List of Waters*, the Aaron River Reservoir, Bound Brook Pond, Bound Brook (from confluence or Aaron River and Herring Brook to Hunters Pond), and the Gulf River (from Hunters Pond to Cohasset Harbor) are Category 3, implying they are unassessed with respect to their designated uses (as described in 6.1 above).

6.3 MONITORING EFFORTS IN GULF RIVER WATERSHED

Existing and historic water quality monitoring sites in the Gulf River Watershed are illustrated in figures 6-1 and 6-2.

Gulf River. Water quality data on air and water temperature, dissolved oxygen, pH, and in some cases fecal coliform was collected by Cohasset High School students in 1990, 1991, 1992, 1994, 1995, 1996, and 1997.

Musquashcut Pond. Monitoring of Musquashcut Pond was carried out in July – September 1999 as part of the Musquashcut Pond Watershed Management Plan (CEI 1999).

Aaron River. The US Geological Survey collected water quality data in the Aaron River between 1969 and 1979 (USGS 2002).

Lily Pond. Short-term sampling of Lily Pond and its tributaries was conducted by Tutela Engineering and Norfolk Ram Group between 1998 and 2002 as part of Cohasset's *Surface Water Supply Protection Plan*.

Sampling locations for this monitoring effort are illustrated in Figure 6-1. Sampling was also carried out by the US Army Corps of Engineers in 1998 as part of the *Cohasset Water Quality Study* (1999).

Peppermint Brook. Sampling of the brook was conducted by the US Army Corps of Engineers in 1998 as part of the *Cohasset Water Quality Study*.

6.4 NUTRIENTS

When assessing water quality, it is important to learn how much inorganic nutrients—such as phosphate, nitrate, ammonia—exist in the water to support algae and other vegetation (i.e., the primary producers). The more nutrients available in a water body, the more plants will grow. While vegetation is vital to the aquatic food chain, too much can cause more harm than good. How do you know when nutrients are causing a problem? Excessive plant growth, loss of species diversity, and foul odors are good indications.

Nutrients such as carbon, silicate, magnesium, potassium, and calcium, all are required for plant growth. But nitrogen and phosphorous are considered the principal nutrients controlling primary production. Phosphorous and nitrogen are "controlling" nutrients because any addition of one or the other to a system increases primary production—an effect commonly referred to as *nutrient limitation*. In freshwater systems, phosphorous is the nutrient that limits primary production while coastal systems are nitrogen-limited.

There are a number of sources of nutrients to an aquatic system. All waters contain low concentrations—also called background levels—of organic nutrients from soils, air, and the life cycle of organisms. Additional organic and inorganic nutrients can be introduced from other sources such as fertilizers, septic systems, wastewater, rainfall, stormwater, and animal waste. When a lot of different sources of nutrients can be identified for a particular water body, nutrient over-enrichment is a potential threat that should be addressed.

Trophic state is related to plant densities stimulated by the amount of nutrients received from the watershed and is a common way of comparing nutrient richness in lakes and ponds. Methods for determining trophic state have varied considerably over the years and no method is considered to be superior or more appropriate. One such method requires measuring the amount of plant pigment (chlorophyll-*a*) and using this number to calculate a Trophic State Index (TSI). *Oligotrophic* systems have low levels of nutrients and a TSI less than 40, *mesotrophic* systems have moderate levels of nutrients and a TSI between 40 and 50, and *eutrophic* systems have high levels of nutrients and a TSI above 50. A TSI above 70 is considered *hypereutrophic*.

Marine waters are typically much more productive then fresh water systems and the same index is not applicable. The terms *eutrophic* and *eutrophication* are often used to describe systems that are overburdened by nutrients. As water is increasingly enriched with nutrients, a process known as eutrophication develops. During eutrophication, plant and algal growth increase. Over time, the water body may exhibit symptoms of eutrophication such as extensive algal slimes or scums, water discoloration, reduced circulation, a decrease in biodiversity, oxygen depletion, fish mortalities, foul odors, and episodes of toxicity. Eutrophication occurs at different rates, depending on the volume and flow rate of the water body, and is generally increased by human inputs of nitrogen or phosphorous (Terrell & Perfetti 1989). The Buzzards Bay National Estuary Program has developed an eutrophication index that combines values of dissolved oxygen percent saturation, secchi disk depth, chlorophyll *a*, total organic nitrogen (TON), and dissolved organic (DIN). Eutrophication index values range from 0 for very eutrophic conditions to 100 for pristine water quality.

The nutrients and their forms that are conveniently and typically measured with proven analytical methods include: soluble orthophosphate, inorganic phosphate (orthophosphate + polyphosphate + insoluble inorganic phosphates), total phosphorous (inorganic + organic), Kjeldahl nitrogen (ammonia + organic nitrogen), and nitrate + nitrite (Allen & Kramer 1972). There are no required or recommended thresholds for nutrients in marine systems at this time. However, through the US Environmental Protection Agency's *National Strategy for the Development of Regional Nutrient Criteria*, there will be waterbody-type guidance for assessing the trophic state of a water body and nutrient criteria appropriate to different geographical regions available sometime in 2003.

Musquashcut Pond. Monitoring of Musquashcut Pond was carried out in July – September 1999 as part of the Musquashcut Pond Watershed Management Plan (CEI 1999). Sampling results indicated increased nutrient levels in the chain ponds just south of Musquashcut Pond and at the southern inlet the pond.

Aaron River. The US Geological Survey collected nutrient data in 1970 and 1971. Ammonia concentrations measured 0.31 mg/l (11/70) and 0.19 mg/l (4/71); nitrite measured 0.009 mg/l (11/70) and was undetectable in 1971; nitrate measured 0.040 mg/l (11/70) and 0.02 mg/l (4/71) (USGS 2002).

Lily Pond. A recent evaluation of Lily Pond found conditions there to be "eutrophic bordering on hypereutrophic," (Norfolk Ram Group 2002). The average TSI obtained for Lily Pond over a 3-year period was 68, with several values exceeding 70. Elevated nitrate concentrations were detected at the Peppermint Brook location in 1999 and 2000, in a region with no storm water control devices. Data collected by the US Army Corps of Engineers in 1998 also found elevated nitrate concentrations in Lily Pond (0.37 mg/l), but could not conclude if this was indicative of any sort of problem (USACE 1999). "For comparison, Connecticut Water Quality Standards give a range typical for mesotrophic lakes of 0.2 to 0.6 ppm [mg/l] total nitrogen in spring and summer," (USACE 1999). Both the Norfolk Ram and Army Corps monitoring efforts also recorded elevated chloride concentrations at the same sampling sites, suggesting that uncontrolled stormwater runoff from roads and lawns was contributing contaminants to Lily Pond (Norfolk Ram Group 2002; USACE 1999).

6.5 BACTERIA

A number of different species of bacteria are used to indicate the presence of harmful pathogens in water. Guidelines and thresholds (i.e., standards) for these bacteria are established by appropriate government agencies based upon how much bacteria a human can tolerate before getting sick.

The present day standard bacterial indicator applied by the Massachusetts Division of Marine Fisheries (DMF) to assess water quality for the purposes of shellfishing is fecal coliform. Shellfish beds classified as open to shellfishing must not exceed concentrations with most probable number (MPN) 14 col/100ml (see the footnote on page 40 for a description of the MPN method). Shellfish beds that are restricted to certified Master Diggers must not exceed concentrations of MPN 88 col/100 ml and these shellfish must be treated by controlled depuration before they are available for consumption. Shellfish beds with concentrations that exceed these standards are closed to shellfishing.

The Department of Environmental Protection applies water quality standards to assess whether a water body is fishable, swimmable, or drinkable. These are the standards presented in Table 6-1. Again, fecal coliform is the chosen indicator of bacterial contamination. More recently, the Department of Public Health has adopted new standards for monitoring beaches, as recommended by the US Environmental Protection Agency. These standards were discussed in the previous section. Instead of fecal coliform, *Escherichia coli* and/or *Enterococcus* are used as bacterial indicators.

Peppermint Brook. Fecal coliform data collected by the US Army Corps of Engineers (1999) found elevated counts of 290 coliforms/100 ml.

Gulf River. Fecal coliform counts were slightly elevated in July 1990 at stations 3 (256 col/100ml) and 4 (363 col/100ml), and in August 1990 at stations 1 (TooNumerousToCount) and 4 (265 col/100ml). In June 1991, station 5 (Peagram Brook) had elevated fecal counts of 960 col/100ml and 528 col/100ml and in July 1991 fecal counts at the same station were TNTC. In December 1992, July and August 1994, and April and May 1995, fecal coliform samples measured below the 200 col/100ml threshold. In October 1996, elevated counts were measured at two stations near Gannet Road, 7A (410 col/100ml) and 7B (210 col/100ml). With the exception of TNTC, these fecal counts are not alarmingly high, but rather are "borderline" exceedences.

6.6 SALINITY

Salinity is the concentration of all dissolved ions (i.e., salts) in a sample. Seawater has a salinity of approximately 35 o/oo (parts per thousand). Brackish water ranges upward from 1 o/oo, and brine is the term used to describe water with salinity greater than 35 o/oo.

Data on salinity within the watershed could not be located for this report.

6.7 TEMPERATURE

A healthy temperature for a body of water depends on location and other physical characteristics. Changes in water temperatures beyond natural seasonal fluctuations play an important role in determining acceptable limits of certain natural elements. Since an increase in temperature increases the solubility of solids and a decrease increases the solubility of gases, temperature changes can prompt water to absorb more of certain elements than it normally would. Consequently, concentrations can become harmful, even toxic, to the ecosystem.

Aaron River. US Geological Survey recorded temperature data in the Aaron River of 12 ^{o}C/54 ^{o}F (10/69), 6 ^{o}C/43 ^{o}F (11/70), 8.5 ^{o}C/47.3 ^{o}F (4/71), and 25 ^{o}C/77 ^{o}F (7/79) (USGS 2002).

Peppermint Brook. The US Army Corps of Engineers (1999) recorded data on temperature in the Aaron River (13.1 ^{o}C/55.6 ^{o}F), Peppermint Brook (12.9 ^{o}C /55.2 ^{o}F), and Brass Kettle Brook (14.8 ^{o}C/58.7 ^{o}F).

Gulf River. In June and July 1991, surface water temperatures ranged from 20 – 23^{o}C (68 – 73.4 ^{o}F). In July and August 1994, temperatures ranged from 20 – 31 ^{o}C (68 – 87.8 ^{o}F) and in April and May 1995, temperatures ranged from 11 – 14 ^{o}C (51.8 – 57.2 ^{o}F).

6.8 DISSOLVED OXYGEN

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in water. Oxygen is introduced to water through organic wastes, diffusion from surrounding air, aeration (rapid and turbid movement of water), and it is a product of photosynthesis. Insufficient dissolved oxygen can significantly degrade the quality of life in a pond, killing fish and vegetation (plants need oxygen at night when they are not photosynthesizing). The growth and reproduction of most plants and animals is unimpaired when dissolved oxygen exceeds 5 mg/l. When levels drop below 5 mg/l, however, living organisms often become stressed. If levels fall below 3 mg/l, the system is at risk of becoming hypoxic, killing many non-mobile organisms and driving mobile organisms away to healthier regions. Another condition, known as anoxia, results when dissolved oxygen levels are reduced to less than 0.5 mg/l. Even fewer species can survive in anoxic conditions.

Gulf River. Between 1991 and 1997, most dissolved oxygen levels in the Gulf River were above 5 mg/l, typically ranging from 10 – 25 mg/l at different locations in the estuary. One exception was on October 1996, when DO of 4.0 mg/l was measured at the Musquashcut Pond tide gate.

The US Army Corps of Engineers (1999) recorded data on dissolved oxygen in the Aaron River (9.2 mg/l), Peppermint Brook (8.4 mg/l), and at two stations in the Brass Kettle Brook (3.4 mg/l and 5.3 mg/l).

6.9 pH

The pH of a sample of water is a measure of the acidity or alkalinity of the water, based on the concentration of hydrogen ions. Water with a pH value of 7.0 is considered neutral. The lower the pH, the more acidic the water is; the higher the pH, the more alkaline it is. The pH of water also determines the solubility and biological availability of nutrients and heavy metals. Metals tend to be more toxic when they are more soluble at lower pH ranges. Most natural waters have a pH ranging from 6.5 to 8.5. Water with a pH outside of this range can seriously disrupt order in an ecosystem and is cause for concern.

The US Army Corps of Engineers (1999) recorded data on pH in the Aaron River (5.7), Peppermint Brook (6.5), and at two locations in the Brass Kettle Brook (5.8, 5.6). "At all stations, pH was at or below the recommended minimum of 6.5 for aquatic life; however, measured levels down to 5.6 are not unusual for New England where acid rain falls on soils of granitic origin which have poor buffering capacity," (USACE 1999).

Gulf River. According to the student data, pH throughout the estuary has ranged from 4 – 8.5. pH values below 5.5 were measured in October 1996 at stations 2 and 5, and in December 1996 at station 1, 5, 7A, and 8. The low December pH could have been due to a recent rain event that might have had high acidity. Absent any data on buffering capacity, it is difficult to ascertain the significance of the October spikes.

US Geological Survey data for the Aaron River measured pH of 6.3 (10/69), 6.2 (9/70), 5.7 (11/70), and 5.2 (4/71) (USGS 2002).

6.10 METALS AND TOXIC ORGANIC CHEMICALS

The US Army Corps of Engineers sampled sediments in the Aaron River, Peppermint Brook, and Brass Kettle Brook for metals, semi-volatile organic compounds (SVOCs), pesticides, and PCBs to provide an indication of contamination from Hingham Annex, Wompatuck State Park hazardous waste site, and Cohasset Heights Ltd landfill. Arsenic, barium, chromium, mercury, lead, and selenium were detected, mostly at low-level concentrations within the range of average levels in the earth's crust and below the Massachusetts Department of Environmental Protection's background soil concentrations used to characterize site risk (USACE 1999). Lead levels in Brass Kettle Brook presented the only metal that was elevated above any reference background level. Lead is a toxic metal that enters the aquatic environment through precipitation, lead dust, erosion and leaching of soil, municipal and industrial waste discharges, and surface runoff. Sampling for this project was too limited to make any determinations on whether there was a particular source for the high lead reading (USACE 1999).

SVOCs strongly bind to sediments, particularly organic sediments. Most of the SVOCs detected, such as polynuclear aromatic hydrocarbons (PAHs), are products of incomplete combustion. Sources including forest fires, incinerators, and car exhaust, they are found all over the world. All other SVOCs detected were plasticizers, "which are compounds added to plastics to control their properties, typically to make them more flexible," (USACE 1999). With one exception, the levels of contaminants measured were similar to those measured in other parts of New England (USACE 1999). Butylbenzyphthalate was reported at higher levels, but not by much. This chemical is considered a low risk hazard and biodegrades quickly.

Sediment samples from Brass Kettle Brook were analyzed for pesticides and PCBs and no detectable concentrations were found, confirming no contamination (USACE 1999).

In 1994, the Department of Public Health issued a statewide advisory on mercury contamination of freshwater fish aimed at pregnant women, which is still in effect (EOEA & DEP 2002).

7. LAND COVER AND LAND USE

Watershed management requires data and information relevant to both *land cover* and *land use*. Land cover is simply what the surface of the land appears to be based on data obtained through aerial photography or satellite imagery. Such data are then classified into land cover categories using different techniques. Land use is the economic use of the land in question. Classification of land use data often requires more information than simple land cover. To illustrate the difference between land cover and land use, imagine an area that is forested. From aerial photography or satellite imagery (i.e. land cover) such land may be classified as "Forest". However if we have local knowledge that the land is being used (i.e. land use) for selective timber harvesting by a paper company, we might classify it as "natural resource extraction".

Land cover data is often used to infer land use, simply because the methods for doing so are relatively inexpensive and the resultant maps are adequate for more regional applications. The land cover map of the Gulf River Watershed is presented in Figure 7-1. This map was derived from MassGIS's Land Use datalayer[6]. The original 21-class map was generalized to 9 classes for sake of illustration and to more appropriately fit the needs of this study.

Figure 7–3 is a true "land use" map of the Cohasset and Scituate components[7] of the Gulf River watershed. This map uses parcel-based data that were obtained from the municipalities. Parcels are the 'economic unit' by which we buy and sell land. Thus, any parcel based data showing the primary use of parcels are a true "land use" map. The original data obtained were classified into 33 land use categories in Scituate and 48 land use categories in Cohasset based on the Commonwealth's Department of Revenue "Guidelines for the Classification and Taxation of Property According to Use - Property Type Classification Codes". These categories were then grouped to fit into a similar classification scheme used for Figure 7–1. It is important to note that this map only represents information on the primary use of the land as determined by the municipality's assessing office. However, just as land cover can infer land use, land use can infer land cover.

7.1 LAND COVER

The Gulf River watershed is comprised of approximately 10,483 acres. Table 7–1 summarizes by acreage and percentage the land cover of the watershed within each town. More than two-thirds of the watershed is contained within the municipalities of Cohasset and Scituate. However, both Hingham and Norwell contain sizeable amounts of the total watershed. Any effort to initiate management or planning for the entire watershed would have to work with all four municipalities for optimal effectiveness.

Table 7-1. Acreage in the Gulf River Watershed by Town

TOWN	PERCENT	ACRES
Cohasset	37	3906
Hingham	10	1013
Scituate	34	3555
Norwell	19	1942

[6] While MassGIS calls this a Land Use datalayer, it is more accurately a land cover datalayer with inferred land use. This data layer depicts a total of 21land use classifications interpreted from 1:25,000 aerial color infrared photography from 1999. As mentioned in the body of the report, land use/land cover is determined from the aerial photographs, the perimeter of each land use area does not coincide with actual property boundaries nor does it necessarily reflect precise land uses.

[7] The Norwell and Hingham components of the watershed were not included because data is not yet available from town officials in digital form.

Table 7-2. Land Cover acreage in the Gulf River Watershed by Town

	Cohasset		**Hingham**		**Norwell**		**Scituate**		***Total Acreage in Class (%age)***
Land Classes	*Acres*	*%age of Total*	*Acres*	*%age of Total*	*Acres*	*%age of Total*	*Acres*	*%age of Total*	
Commercial/Industrial/ Institutional	126	(1.2%)	0	(0.0%)	0	(0.0%)	30	(0.3%)	*160 (1.5%)*
Other - Waste Disposal/Mining	4	(0.04%)	0	(0.0%)	3	(0.03%)	0	(0.0%)	*8 (0.08%)*
Residential	1128	(10.8%)	0	(0.0%)	286	(2.7%)	1251	(11.9%)	*2696 (25.7%)*
Agriculture	7	(0.07%)	5	(0.05%)	60	(0.6%)	39	(0.4%)	*113 (1.1%)*
Recreational	27	(0.3%)	35	(0.3%)	0	(0.0%)	78	(0.7%)	*141 (1.4%)*
Open Land	121	(1.2%)	38	(0.4%)	26	(0.3%)	63	(0.6%)	*247 (2.4%)*
Forest	2182	(20.8%)	907	(8.7%)	1528	(14.6%)	1786	(17.0%)	*6413 (61.2%)*
Wetlands	139	(1.3%)	10	(0.1%)	18	(0.2%)	307	(2.9%)	*493 (4.7%)*
Water	172	(1.6%)	18	(0.2%)	21	(0.2%)	1	(0.01%)	*212 (2.0%)*
Total Acreage in Town	*3906*	*(37.3%)*	*1013*	*(9.7%)*	*1942*	*(18.5%)*	*3555*	*(33.9%)*	**10,483 (100.0%)**
									Total Acreage

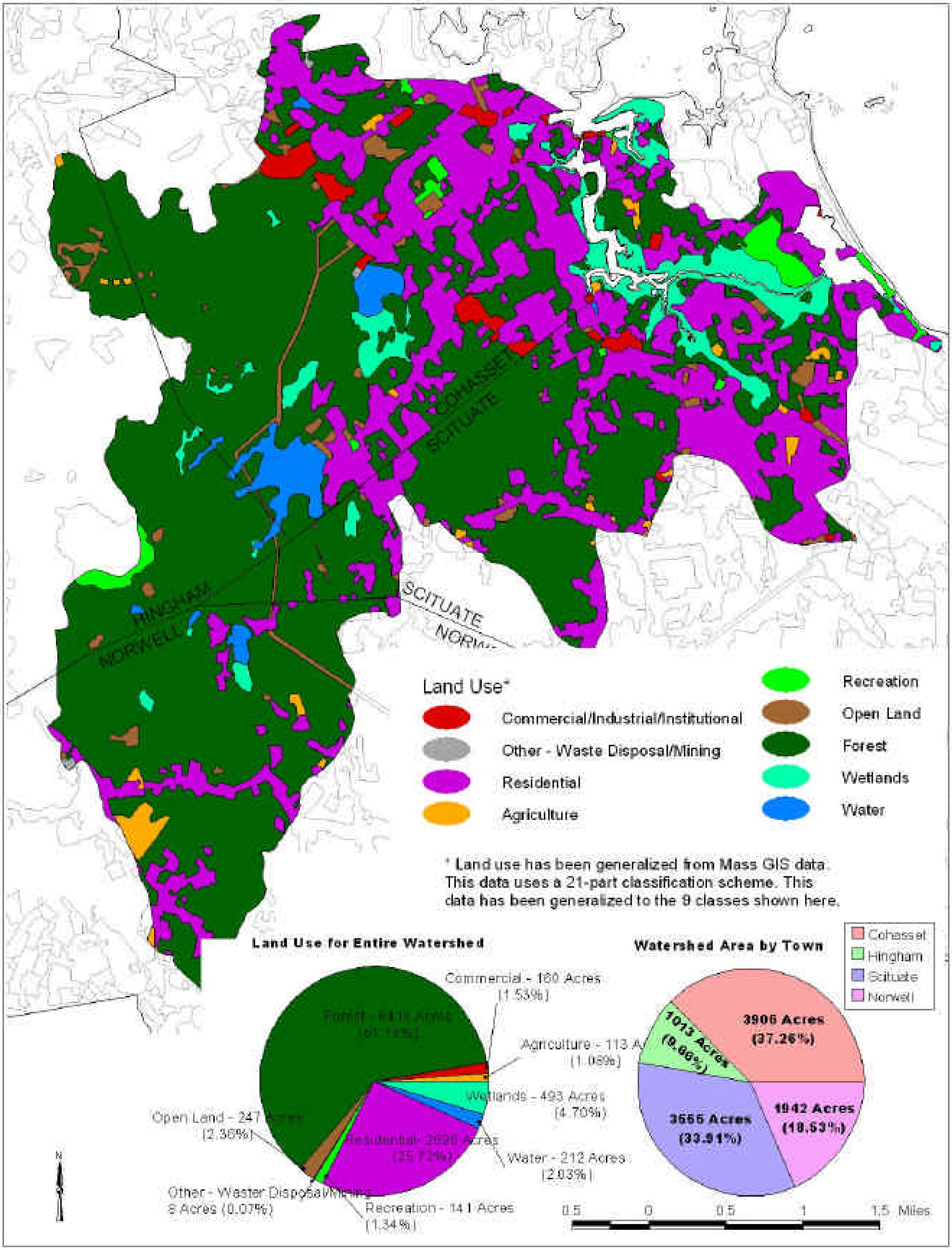

Figure 7-1. Land Cover in the Gulf River Watershed

Land Cover for those areas within the watershed is summarized in Table 7-2 and presented in Figure 7-1. The land use classification scheme and figures were compiled from MassGIS's Land Use theme.

The greatest percentage of the watershed is in the Town of Cohasset, with areas immediately adjacent to the Gulf River, as well as in the upper reaches of the watershed. Cohasset is a predominantly residential community of nearly 10 square miles with a population of 7,075 (2000 Census) and an overall population density of 704 persons per square mile. Several areas of the town are sewered (1,148 homes in all). Land cover/land use in the area within and immediately adjacent to the study area in Cohasset is predominantly low density residential (> ½ acre/house). As Figure 7–1 shows the further away from the Gulf River and the coast in general, the more the land cover begins to revert to forest.

The Town of Scituate also contains a large proportion of the watershed, again both immediately adjacent to the Gulf River as well as in the upper reaches of the watershed. Like Cohasset, Scituate is predominantly a residential community. It covers nearly 17 square miles and has a population of 17,863 (2000 Census). Its population density is 1,063 people per square mile. Again, similar to Cohasset, areas within and immediately adjacent to the study area tend to be low density residential, although wetlands seem to predominate close to the Gulf River itself. The pattern of forest reversion further from the coast and the Gulf River is also present in Scituate.

Norwell contains nearly a fifth of the total watershed, mostly in the upper reaches. Norwell's population is 9,765 (2000 Census) and its land area is 21.2 square miles, giving it a population density of 461 people per square mile. Much of the watershed land cover in Norwell is forest and what commercial/residential land cover exists is clustered along major roadways (not shown). Norwell also contains the largest area of agricultural cover within the watershed.

The Town of Hingham covers an area of 22.5 square miles and has a population of 21,751 (2000 Census) with a density of 882 per square mile. Much of the area within Hingham that is part of the watershed is also part of Wompatuck State Park. Wompatuck State Park is a former military installation that has been converted into parkland. As a former military installation, there are some issues associated with the historical disposal of hazardous waste on the property. However, its designation as a state park makes it likely that it will be preserved in a relatively undisturbed state for the foreseeable future.

As Table 7-3 and Figure 7-1 clearly illustrate, slightly more than two-thirds (68 percent) of the watershed land cover appears to be unaffected by development. The remaining third (32 percent) of the land cover in the watershed seems to be impacted by human use. A further examination of Table 7-2 and Figure 7-2, as well as Table 7-3, reveals that most of the human impact in the form of changing land cover is to be found in the municipalities of Cohasset and Scituate. Norwell and Hingham, although constituting smaller proportions of the watershed, also constitute proportionally smaller amounts of human impacted land cover than Scituate or Cohasset. This suggests that any watershed management initiatives concerning land cover change should focus on preserving existing land cover in Hingham and Norwell and finding ways to limit impacts in Cohasset and Scituate.

Table 7-3. Percent of Disturbed/Undisturbed Land Cover in the Gulf River Watershed by Town

	Cohasset	Scituate	Cohasset & Scituate	Norwell	Hingham	Total
Undisturbed*	64	59	*61*	81	92	*68*
Disturbed**	36	41	*39*	19	8	*32*

*Undisturbed classes - “Forest”, “Wetlands”, and “Water”

**Disturbed classes - “Commercial/Industrial/Institutional”, “Other – Waste Disposal/Mining”, “Residential”, “Agriculture”, “Recreation”, and “Open Land”

An example of the effects of land cover disturbance is illustrated by examining impervious surface cover. A surface is considered impervious if it has been covered or compacted with a layer of material that substantially reduces or prevents rain or storm water from filtering into the ground. Estimates of impervious cover for disturbed land cover classes have been developed by University of Rhode Island’s Department of Natural Resources Science Cooperative Extension (Joubert *et al*. 2000) for use with the original 21 class data provided by MassGIS. Using these impervious surface coefficients, estimates of the total amount of impervious surface within the watershed, the distribution of impervious surfaces and the contribution each municipality makes to impervious surfaces within the watershed can be examined. Figure 7–2 illustrates these estimates. Approximately 767 acres, or 7.32%, of the entire watershed is covered by impervious surfaces. As anticipated, the density of impervious surfaces seems to increase the closer one gets to the Gulf River and the coast and along major thoroughfares (not shown). In addition to this, the grey bars clearly show that the towns of Cohasset and Scituate contribute the bulk of impervious surfaces to the watershed, above the proportion of the contribution to the total land area of the watershed as represented by the blue bars.

Build-out analyses have been performed by the Executive Office of Environmental Affairs and the Metropolitan Area Planning Council for each of these four communities within Gulf River watershed. These analyses were done using the MassGIS data and thus do not take into account individual parcels. As such, these analyses were done as part of a ‘visioning’ exercise and to estimate a town’s land cover composition at build out. The final product was a Land Use datalayer at build out, similar to the land use theme presented in Figure 7-1. These build out analyses have been distributed to the municipalities. Similar analyses and summary statistics to those presented here concerning land cover could be done using the build-out data, to get a sense of future land cover. Town specific data on the number of additional housing units and additional residents at build-out can be estimated through this process.

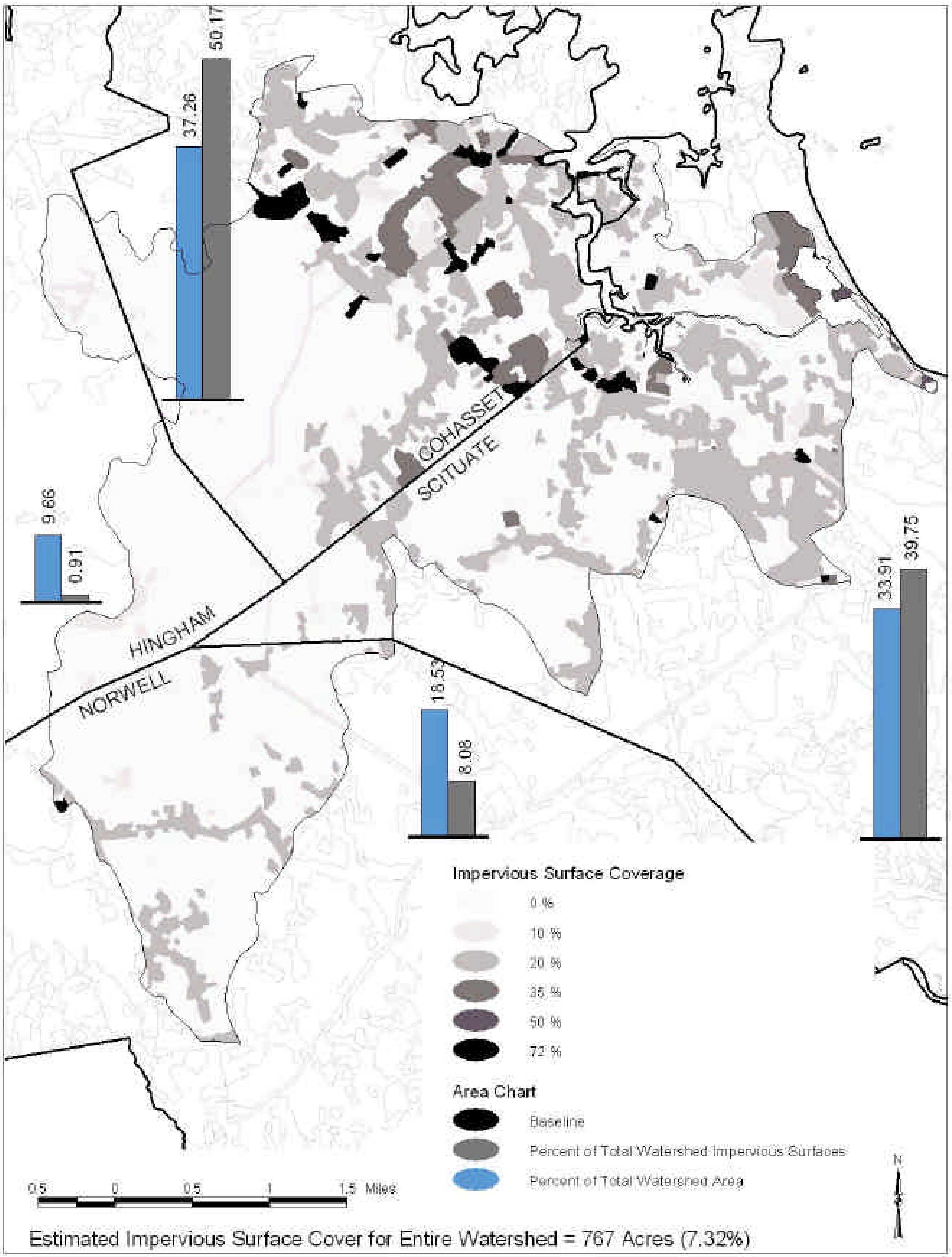

Figure 7-2. Percent Impervious Surface Coverage in the Gulf River Watershed

7.2 LAND USE

As mentioned earlier, land use is the *economic use* of a particular parcel of land. This is often determined by an examination of the town assessor for taxation purposes. This use data is then "attached" to a particular parcel, irregardless of the actual land cover. Figure 7-3 presents a land use map of Cohasset and Scituate parcels within the Gulf River Watershed.

Table 7-4. Land Use acreage in the Gulf River Watershed by Town

	Cohasset		*Scituate*		***Acreage for Both Towns in Class (%age)***	
Land Classes	*Acres*	*%age of Total*	*Acres*	*%age of Total*		
Commercial/Industrial/ Institutional	535	(13.5%)	308	(8.7%)	*843*	*(11.2%)*
Residential	1273	(32.1%)	1560	(43.8%)	*2833*	*(37.7%)*
Agriculture	8	(0.2%)	45	(1.3%)	*53*	*(0.7%)*
Recreational	0	(0.0%)	89	(2.5%)	*89*	*(1.2%)*
Open Land	672	(17.0%)	569	(16.0%)	*1241*	*(16.5%)*
Forest & Wetlands	885	(22.3%)	30	(0.8%)	*914*	*(12.1%)*
Water	51	(1.3%)	5	(0.1%)	*55*	*(0.7%)*
Government	541	(13.7%)	289	(8.1%)	*830*	*(11.0%)*
Unknown	0	(0.0%)	666	(18.7%)	*666*	*(8.8%)*
*Total Acreage in Town**	*3964*	*100%*	*3561*	*100%*	**7525**	**(100.00%)**
					Total Acreage	

*Acreage in towns is slightly different from Land Cover data sets due to differences in data gathering methodologies.

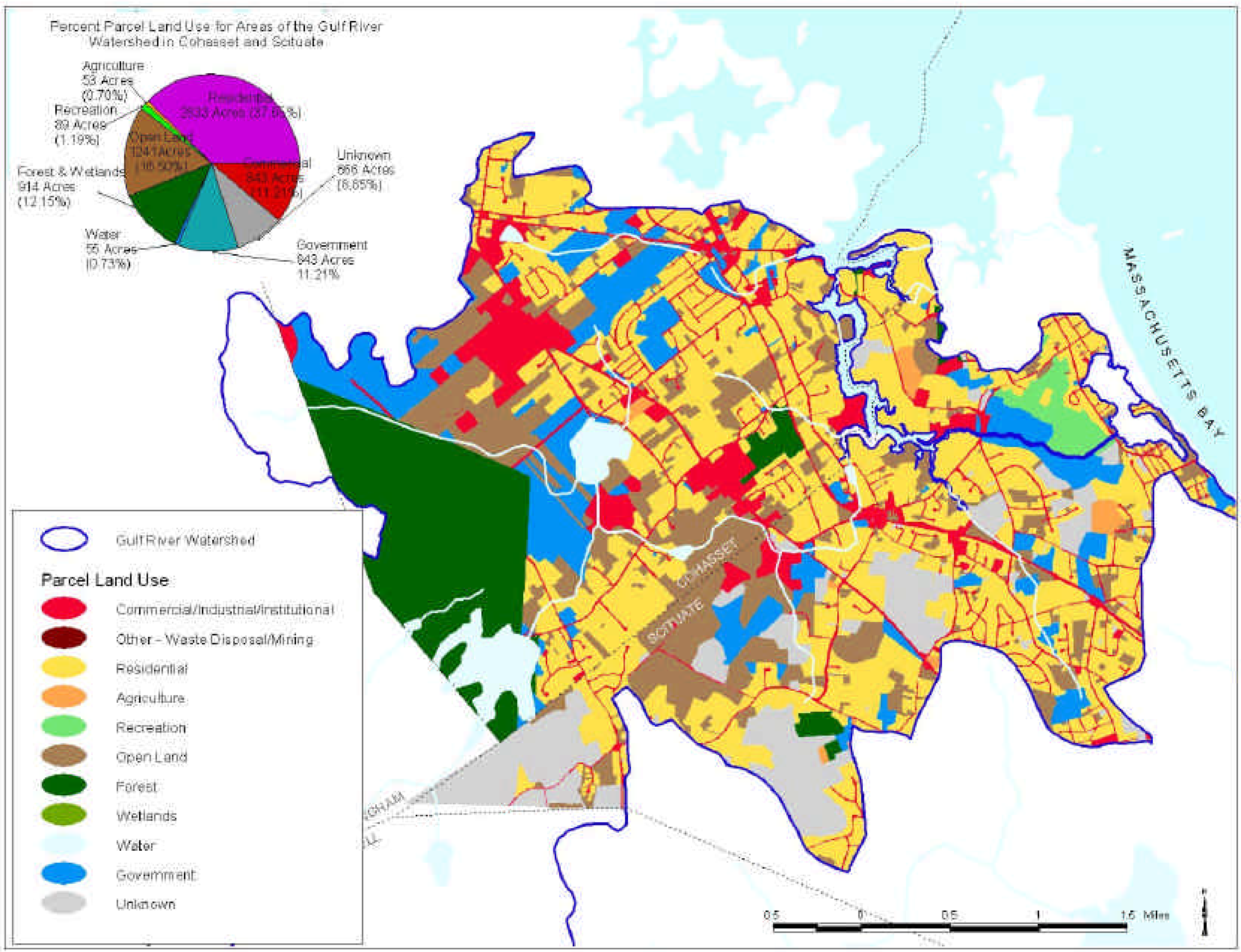

Figure 7-3. Cohasset and Scituate Land Use in the Gulf River Watershed

An examination of land use by parcel gives a very different picture than land cover. Using a similar classification scheme as used for land cover[8], Table 7-4, Figure 7-3, and summary Table 7-5 show that the primary land use of more than two-thirds of the parcels in the watershed contributes to disturbance of the 'natural' features. Using comparisons of Tables 7-3 and 7-5 and Figures 7-1 and 7-3, it can be inferred that a large amount of the undisturbed cover lies on parcels whose primary use is one that tends to disturb the 'natural' cover. This is an important inference, because it suggests that effective means to preserve 'natural' cover should not entirely focus on new zoning regulations, which tend to affect future land uses, but instead to focus on incentives, regulations, and education programs to insure individual parcel owners preserve the 'natural' cover on their own land.

Table 7-5. Percent of Disturbed/Undisturbed Land Use in the Gulf River Watershed by Town

	Cohasset	Scituate	Cohasset & Scituate
Undisturbed*	37.2	9.1	23.9
Disturbed**	62.8	72.2	67.2
Unknown	0.0	18.7	8.9

* Undisturbed Classes - "Forest & Wetlands", "Water", "Government"

* Disturbed Classes - "Commercial/Industrial/Insitutional", "Residential", "Agriculture", "Recreational", "Open Land"

8 This scheme differs only in the addition of a "Government" and "Unknown" class and the subtraction of a "Wetlands" and "Other – Waste Disposal/Mining" class.

8. OPEN SPACE AND RECREATION

8.1 OPEN SPACE IN SCITUATE AND COHASSET

The Commonwealth of Massachusetts provides public, private, and non-profit open space with varying degrees of protection. Massachusetts General Law (MGL) Chapter 61 provides an incentive to landowners not to develop their land and to conserve it for forestry, agricultural or recreational uses. Qualifying lands are assessed at a "use value" rate rather than at a "development value" rate, therefore reducing the tax burden on the landowner. Under these programs, landowners receive tax breaks in exchange for managing the land for the purposes stated. If the landowner decides to sell the land, they lose the tax benefits and the town has the right of first refusal to purchase it. Private holdings that are recognized under this system include:

> *Forest Land (Chapter 61)*: parcels of land used for forest production and that are not less than 10 acres in area can be designated as forest land.
>
> *Agricultural or Horticultural Land (Chapter 61A)*: parcels of land that are used directly for commercial farming, or land that is used in a way that directly supports farming can be designated agricultural land.
>
> *Recreational Land (Chapter 61B)*: parcels of land that are retained in a largely natural, wild, or open condition or in a landscaped condition and allow for the preservation of wildlife and other natural resources can be designated as recreational land. This can also include land that is primarily for recreational use. Recreational uses include: hiking, camping, nature study and observation, boating, golfing, horseback riding, hunting, fishing, skiing, swimming, and picnicking.

Other open space that is recognized by the Commonwealth includes: federal, state or municipal open space, significant areas for water resource protection (high yield aquifers), priority areas for protection of rare species, private recreation areas, estates, major institution land holdings, and less-than-fee-interests. Less-than-fee-interests are lands encumbered by conservation restrictions, wetland restrictions, watershed protection restrictions, and historic preservation restrictions.

Based on the Assessors GIS databases, Scituate has 29 parcels that are designated as Chapter 61 land (45 acres), Chapter 61A land (154 acres) or Chapter 61B land (246 acres). Cohasset has 32 parcels designated as Chapter 61 land (62 acres), Chapter 61A land (8 acres), or Chapter 61B land (171 acres). In Cohasset, these are located in 4 distinct groups (Table 8-1).

However, given the number of parcels and the acreage involved in Scituate (a total of 445 acres) and Cohasset (240 acres), it is unlikely that either town could purchase all the land that may be deemed valuable (Cohasset Open Space Advisory Committee 2001; EOEA 2001; Town of Scituate 2001). In Scituate, many of the protected parcels are private property that is not designated by Chapter 61, 61A or 61B. While these may be protected at this time, they are not protected in perpetuity as open space. "In fact, a number of them—including some of the largest—are held by private landowners without long-term assurances that they will not be developed at some time in the future. The Hatherly and Scituate Country Club golf course land, combined with the Glades Corporation compound, account for 350 acres of unprotected open space," (Town of Scituate 2001).

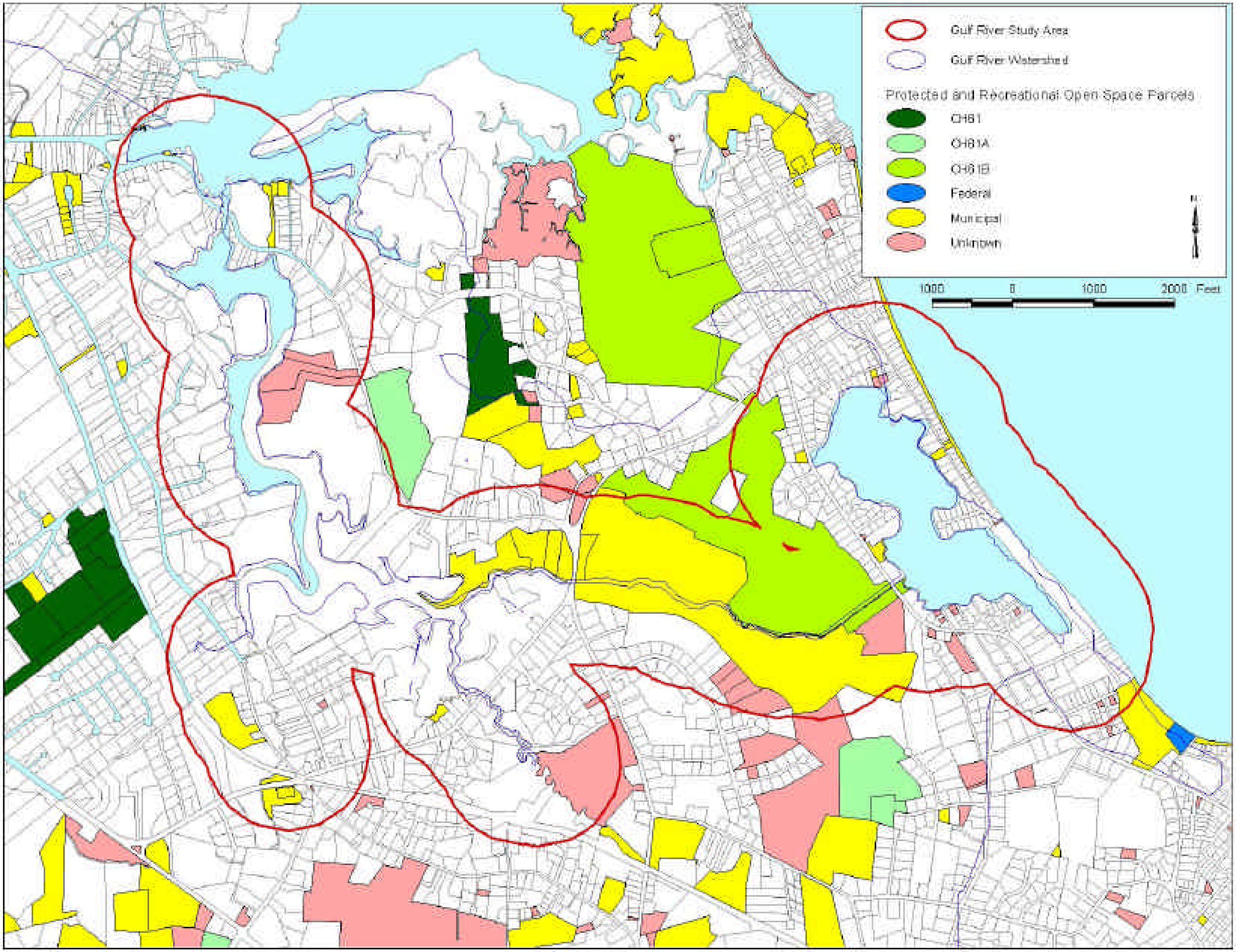

Figure 8-1. Protected and Recreational Open Space Around the Gulf River Based On Parcel Data (Data Source: Town's of Scituate and Cohasset, MassGIS).

Table 8-1. The Acreage and Number of Parcels with Chapter 61, Chapter 61A and Chapter 61B Designation within the Towns of Cohasset and Scituate based on the Assessors GIS Database.

	Cohasset		Scituate	
	Acres	#	Acres	#
Chapter 61	61	19	45	8
Chapter 61A	8	2	154	11
Chapter 61B	170	11	246	10
TOTAL	240	32	445	29

Both Scituate and Cohasset have developed and implemented open space plans, Scituate in 1998 and 2001 and Cohasset for 2002-2006.

Scituate has rich environmental resources such as its beaches, ledge outcroppings, scenic vistas, and numerous agricultural and historical sites that add value to the town, and also the region (Town of Scituate 2001). Scituate has a history of preserving land to maintain its rural character. Overall, 20 percent of the property in Scituate is either protected open space or land that is considered unsuitable for development. In fact, public entities and private nonprofit conservation groups own approximately 2,150 acres of open space within the town (Town of Scituate 2001). However in its various plans, the town has repeatedly underscored the importance of working cooperatively within regional plans (e.g., MetroPlan 2000 (MAPC)) and state plans (e.g., Statewide Outdoor Recreation Plan), as well as in consultation with neighboring towns.

Thirty percent of land in Cohasset is protected open space. This space is primarily located in Wompatuck State Park (1,051 acres) and the Whitney and Thayer Woods (Cohasset Open Space Advisory Committee 2001). The Trustees of Reservations and the Conservation Commission are two of the main holders of protected properties in Cohasset. Public open space includes federal, state, county, and municipal lands and facilities for conservation and recreational use. Non-profit open space is usually associated with a local land trust or similar private non-profit. Land belonging to public institutions such as state and federal schools or universities, state hospitals, and prisons is also sometimes considered as open space (EOEA 2001).

The Town of Cohasset voted to accept the provisions of the Community Preservation Act (CPA) at municipal elections in 2000. The CPA is statewide enabling legislation that allows cities and towns to create a local Community Preservation Fund with a surcharge of 1.5 percent of the real estate tax levied in the municipality. The funds are used for open space acquisition, historic preservation, and low to moderate-income housing.

8.2 OPEN SPACE WITHIN THE GULF RIVER STUDY AREA

Within the study area there are 246 acres of land that could be classified as open space. However, 52 acres of the open space within Scituate have no clear designation in the Town Assessors GIS database. It is therefore likely that some of the parcels are not true open space and that the acreage of open space is less than 246 acres.

The Town of Scituate has jurisdiction over the most open space within the study area (120 acres). The second largest area is 73 acres that is owned by the Hatherly Country Club (Figure 8-1, Table 8-2) and designated as Chapter 61B land. There is also a narrow strip of land just to the south of Musquashcut Brook, where it enters Musquashcut Pond, that is also designated as Chapter 61B land and is also part of the Country Club. The Club's land also extends northwards outside of the study area and this also has a Chapter 61B designation.

The study area contains less than one acre of Chapter 61A land. This is a small section of a 17-acre parcel that is located to the east of the Gulf River along Border Street—the location of Lion's Head Organics. Approximately 1,400 feet south of Musquashcut Brook there are two more Chapter 61A parcels covering a total area of 19 acres.

There are no areas with Chapter 61 designation within the study area. The closest is a group of 13 parcels, covering over 40 acres that lies just to the northwest of Hunters Pond. The only other areas with Chapter 61 designation are two parcels to the east of the Gulf River. These cover a total of over 16 acres and are located between Lion's Head Organics and the northern section of Hatherly Country Club.

Table 8-2. Acreage of Protected and Recreational Open Space within the Gulf River Study Area
Data from the Assessors Offices of the towns of Cohasset and Scituate

Type of Open Space	Acreage
CH61A	1
CH61B	73
Municipal	120
Unknown	52
TOTAL	246

8.3 RECREATION

Most of Scituate's open space properties are accessible to the public. These properties provide a wide range of active recreational opportunities including bicycling, boating, hiking, hunting, playgrounds, swimming, and town-sponsored recreational activities such as youth programs. Recreational developments like the Boston to Cape Cod bike trail require open space. These properties also offer passive recreation such as nature study and wildlife observation.

Boating is popular in both Scituate and Cohasset. Scituate Harbor is in high demand as a stopover for boaters as it is one of the few harbors in the area that remains open year round. As the number of boats has increased, the area available for water recreation has declined (Town of Scituate 2001).

Kayaking is popular on the Gulf River as its tidal cycle and the reversing falls create waves and white water from Cohasset Harbor up the river. The Gulf River estuary has a narrow, 100-yard long channel that separates the Gulf from the harbor. When the high tide ebbs, the channel flows continuously like a river, until slack water at low tide gives way to the returning ocean waters. Then the Gulf begins to refill as the ocean water pours back in the channel. A dam was built near the harbor end; most likely part of a large corn mill built at the start of the 19th century. The remaining walls of the dam and the tidal flow create exciting water conditions for kayakers that are hard to find elsewhere in Massachusetts (JGoodnough 2002).

9. ENVIRONMENTAL CONCERNS AND POLLUTION SOURCES

9.1 MUSQUASHCUT POND

Musquashcut Pond is a shallow, brackish, 70-acre pond in northeastern Scituate. While the pond has figured prominently in the development of Scituate and adjoining areas, it suffers from chronic water quality problems.

In colonial times, Musquashcut Pond was a Great Pond[9] surrounded by farmland (Paley 2002). In 1851, a hurricane breached the barrier beach that separated the pond from Massachusetts Bay, transforming the pond into a small harbor (Paley 2002). The surrounding farm was wiped-out by the storm and the owner subdivided the land, selling-off individual parcels to Bostonians looking to establish summer residences. By the 1930s, the barrier beach had reestablished through natural processes and once again Musquashcut Pond was a Great Pond. Numerous houses lined the pond's perimeter, which had grown into a popular summer retreat, as well as a breading ground for midges. Annoyed by their frequent swarms, the Town appealed to the Massachusetts legislature for a solution to the midge problem. At this time, it was decided that the pond be flooded and that tide gates be installed between the pond and Musquashcut Brook to maintain adequate water depth. Water was exchanged once per month on the full moon high tide, which remains—more or less—the practice today (Paley 2002; Sullivan 2002). Over the years, there have been a number of structural problems with the tide gates (Wells 1990).

It is suspected that the midge population density in the pond is cyclical, with some years being much more intense then others. Efforts to eliminate the midges over the years have included the application of oil to the pond's surface to smother the larvae and, more recently, the seasonal application of the insecticide Abate 1-sg (CEI 1999; Paley 2002). Temephos, the active chemical in Abate, is a Cholinesterase (ChE) inhibitor—a type of neurotoxin. ChE-inhibiting insecticides have been linked to impaired neurological development in fetuses and infants, chronic fatigue syndrome, and Parkinson's Disease (Orme & Kegley 2002). Temephos is considered a low level toxin and is non-carcinogenic. LD50-tests[10], however, confirm temephos is an aquatic toxin particularly harmful to mummichogs (Orme & Kegley 2002). The Town of Scituate ceased spraying Abate approximately four years ago, at which time they planned to switch to a methoprene-based insecticide. Methoprene is considerably less toxic to mummichogs and other aquatic organisms than temephos, and it is neither a ChE-inhibitor nor a carcinogen (Orme & Kegley 2002). However, methoprene is proven to break down into harmful chemical by-products when exposed to sunlight, heat, and organic matter (Mezquida 2000), and it has been linked to frog deformities in Connecticut and Minnesota (Meersman 1999; Mezquida 2000).

Recognizing that pesticides are only a short-term solution to a chronic problem in the pond, local residents filed an adjudicary appeal with the Department of Environmental Protection's Office of Administrative Appeals to prevent the town from spraying with methoprene in 1998. Preserve our Pond, as the citizens group is known, has filed an appeal with DEP for the past four years to prevent spraying (Paley 2002; Reid 2000). The basis for the appeal has been that the Town of Scituate lacks the authority to conduct spraying because it does not own the pond and because "exclusive authority to conduct the spraying program lies within the Department pursuant to M.G.L. c. 111, sec. 5F, which concerns the control of aquatic nuisances," (DEP 2001). While it was decided that MGL c.111 sec. 5 does not prevent the town from conducting the proposed spraying, the appeal has been upheld on the basis that the town has not "demonstrated that it has a colorable claim of authority to conduct the proposed work," (DEP 2001). Preserve Our Pond filed another appeal to prevent spraying in the spring of 2002 and are awaiting DEP's decision on this matter (Paley 2002).

The midge problem in Musquashcut Pond is largely driven by organic nutrient enrichment from failing septic systems (CEI 1999; Paley 2002; Reid 2000). Lawn fertilizers, yard waste, and surface runoff are also sources of pollution to the pond. Storm drains in Sheeps Pond, which is artificially connected to

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[9] According to 310 Code of Massachusetts Regulations (CMR) 9.02, a Great Pond is a pond with a surface area in excess of 10 acres. Title to these ponds are held by the Commonwealth in trust for the public.

[10] LD50 refers to the lethal dose of poison required to kill 50 percent of test animals.

Musquashcut Pond to the south by an overgrown canal, are a suspected but unconfirmed source of contaminants (CEI 1999).

In addition to high nutrients, pathogens from sewage, nuisance midges, and potential sediment contamination from years of pesticide application, Musquashcut Pond suffers from thermal pollution. The shallow depth and slow flushing rates in the pond result in high water temperatures that encourage the growth of weeds. The dense weeds further reduce circulation and, in turn, encourage temperatures in the pond to rise.

Other ecological problems associated with the temperature and chemical imbalances in the pond are evidenced in the decline in fish populations. Less than 20 years ago, Musquashcut Pond was teaming with fish, mostly eels and mummichogs. At times "the fish were so dense they would churn the water," (Paley 2002). In 1990 and 1991, the Massachusetts Division of Marine Fisheries stocked the pond with white perch in an effort to control midges (Brady 2002b). These efforts were unsuccessful because river herring are filter feeders as opposed to bottom feeders and as such were unable to adequately control the midges (Brady 2002b). Further, residents suspect that the pesticide applications resulted in massive mortalities of the fish (Paley 2002). Now there are no eels in the pond and few mummichogs. The fish, it was assumed, had tremendous ecological value as they would feed on the midge larvae, helping diminish their numbers (Wells 1990). According to the Massachusetts Division of Marine Fisheries and Massachusetts Division of Fisheries and Wildlife, stocking a pond such as Musquashcut for the purpose of midge control is challenging. Because of variable salinities in the pond and variable midge populations (i.e., food supply) from year to year, it would be difficult to match a natural predator to this environment (Brady 2002b; Hurley 2002).

A growing population of mute swans in Musquashcut Pond is another concern among residents. As in Straits Pond, a salt pond in northeast Cohasset, these swans are likely contributing to nutrient enrichment of the pond. "Adult swans weigh between 20 and 40 pounds, and each day consume 10 pounds of plant life. The nutrients in the swans' excrement, which is about the size and shape of that produced by dogs, are feeding an overgrowth of aquatic plants and algae," (Preer 2001). In addition to contributing to pollution, the swans are aggressive (Paley 2002) and their presence keeps other water birds away. The swans, which are not native to America, are considered to be a threat to native species populations (Gould 1998).

Plans are underway to study water flow and exchange in Musquashcut Pond and it is expected that the US Army Corps of Engineers Flood Plain Management Services will conduct a flushing study of the pond within the next year (Hatfield 2002). This investigation would likely include modeling and flushing for the Gulf River estuary (Hatfield 2002). The Massachusetts Office of Coastal Zone Management also plans to develop an action plan for Musquashcut Pond that will include some baseline habitat and water quality monitoring to better understand the system (Burtner 2002b). In addition, the residences surrounding the pond are scheduled for sewering in the next five or six years (Paley 2002; Sullivan 2002).

9.2 LILY POND

Nutrient enrichment from land-based sources is a serious problem that threatens the viability of Lily Pond as a drinking water source for the Town of Cohasset. *The Surface Water Supply Protection Plan For Lily Pond and Aaron River Reservoir* (Norfolk Ram Group 2002) addresses this concern and offers a number of recommendations for reducing nutrient loading into the watershed. It is suspected that flow from Peppermint Brook, which flows through a densely developed portion of the watershed, contributes much of the nutrients from below ground septic systems (Norfolk Ram Group 2002). In 2000, Cohasset extended its sewer system to include over 750 houses in the vicinity of Peppermint Brook. Depending on the speed at which ground water travels in that area, it may take several years before decreases in nutrients from the septic systems are observed in Lily Pond.

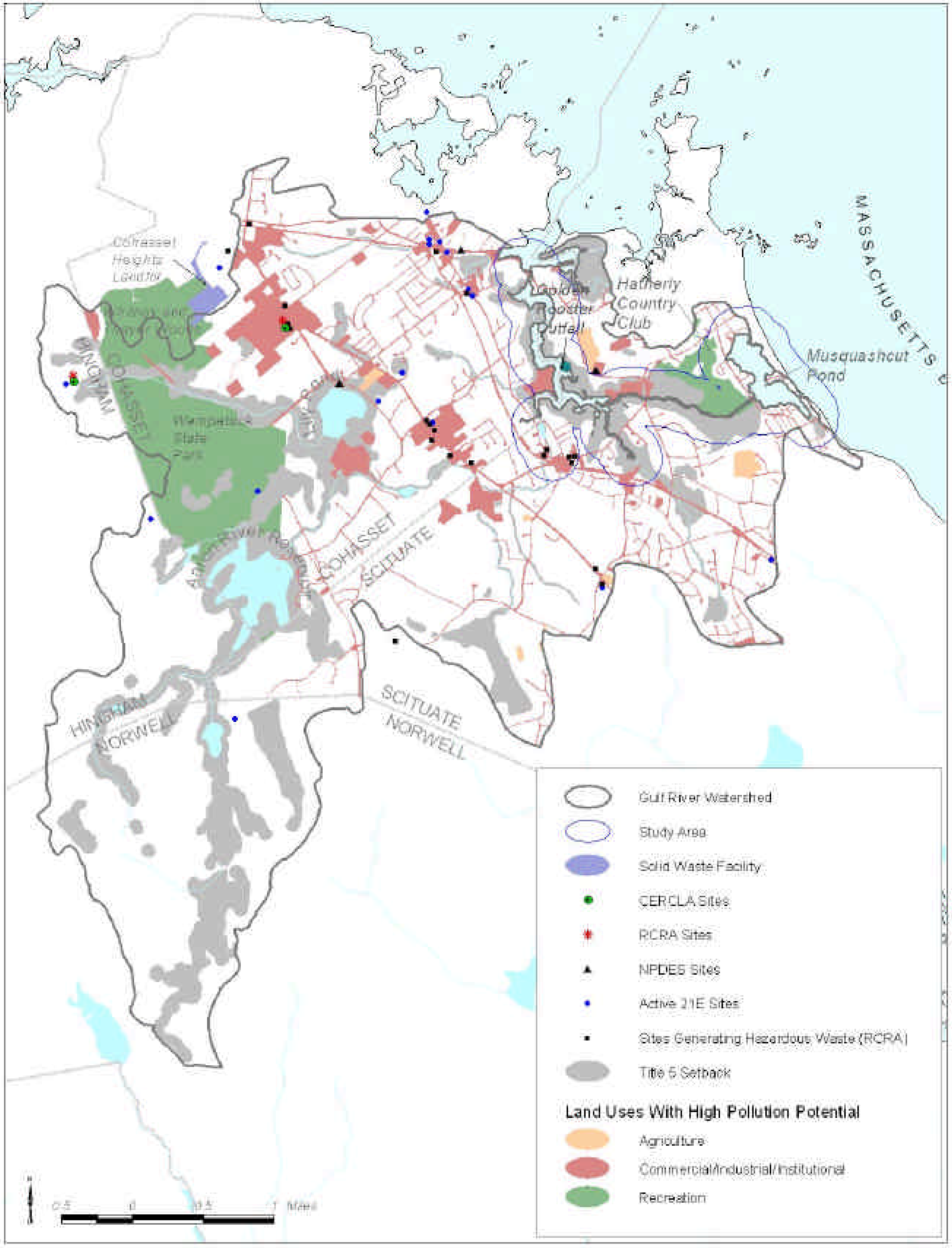

Figure 9-1. Gulf River Watershed Pollution Source Map.

9.3 GEOLOGY, SOILS, AND GROUNDWATER

Maintaining high quality ground water is important in maintaining good environmental quality throughout the watershed. The Gulf River estuary watershed is underlain primarily by bedrock and it is suspected that fractures in the bedrock exist throughout the watershed (Norfolk Ram Group 2002). In the absence of fractures, bedrock has very low permeability. However, when fractures are present, ground water will flow along them; the greater the number of fractures, the greater the flow. The major disadvantages for such flow are that (1) the flow is faster, which speeds up the movement of any contaminants present in the ground water, and (2) the bedrock does not provide much opportunity for contaminants to be filtered compared to flow through soil.

In addition to the presence of fractures, another hindrance to ground water quality is the relatively thin layer of soils that overlay the bedrock in many locations. Many of these soils in the vicinity of the Gulf River estuary and elsewhere in the watershed have either very low or high permeabilities, which impair the soils ability to adequately filter nutrients either because the water moves through it too quickly or because it moves so slow it collects and runs off the surface instead.

9.4 LAND USE POLLUTANTS

General. Examining land use is an important part of an initial survey for contaminant sources. While the data provided by municipalities did not contain enough specific parcel level information to determine specific land use practices on a parcel, the Massachusetts Department of Environmental Protection's Source Water Assessment Program has developed a "contamination matrix" linking these specific land use practices to possible chemical contaminants (see Appendix C). These specific land use practices are enumerated as part of a national Standard Land Use Coding manual compiled by the U.S. Department of Transportation. Classifying parcels by these codes could lead to an inventory of *potential* contaminants of concern and their *possible* source locations. Such information could be displayed through a Geographic Information System (GIS) as an initial "first cut" to determine local sources of water contamination.

Hazardous Waste Generators. As part of the Resource Conservation and Recovery Act (RCRA) Program, the US Environmental Protection Agency (EPA) maintains a database of facilities and businesses that generate hazardous waste (USEPA 2002a). Within the Gulf River watershed the facilities in Table 9-1 and illustrated Figure 9-1, were identified. Contaminants associated with these land uses can be identified in Appendix C.

RCRA was promulgated in 1976 to amend the Solid Waste Disposal Act of 1965. RCRA and the Solid Waste Amendments of 1984 establish a number of federal programs to manage solid waste, hazardous waste, and underground storage tanks. RCRA Subtitle C establishes the program to manage hazardous waste to ensure it is handled in a manner that protects human health and the environment (USEPA 2002b). All persons who generate, transport, treat, store, or dispose of hazardous waste are required to notify EPA and obtain a unique EPA Identification Number. This number is labeled on all manifests when hazardous material is disposed and copies of the manifest are sent to both EPA Region 1 and the Massachusetts Department of Environmental Protection Bureau of Waste Management. In addition, EPA conducts routine compliance and evaluation inspections of facilities that generated hazardous waste.

Table 9-1. Land Uses that Generate Hazardous Waste (adapted from USEPA (2002))

Facility Name	Address	Use
Buckley & Scott	340 Gannet Rd	
Sunoco Service Station	348 Gannet Rd	Gas station
Staneet Cleaners	363 Gannet Rd	Dry cleaner
So. Shore Publishing	777 Country Way	Printer and blueprint shop
Treasure Chest Advertising	777 Country Way	unknown
Wilder Bros. Tire	788 Country Way	Auto repair shop
Cohasset Collision Center	179 Rte 3A	Auto repair shop
O'Brien Nissan	742 Rte 3A	Auto delear/repair
Dwyers Fabricare Center	754 Rte 3A	Dry cleaner
Walgreens	767 Rte 3A	Photo lab
Sunoco Service Station	781 Rte 3A	Gas station
CVS	790 Rte 3A	Photolab
Mitchells Repair Shop	805 Rte 3A	Auto repair
Spensley Chevrolet	828 Rte 3A	Auto repair
Mobil Oil	Rte 3A & Sohier	Gas station
Exxon	Rte 3A & Beechwood	Gas station
Seavy Engineering	135 King St	Manufacture of radar equip.
H&W/Norfolk Conveyor	155 King St	Manufacture of radar equip.
Mediclab Xray	12 Parkingway	
Cohasset Service Center	151 S. Main St	Gas station
Robbins Garage	405 N Main St	Auto repair
Dauphine Auto Body	364A Thomas Clapp Rd	Auto repair shop

Solid Waste Facilities. Cohasset Heights Landfill (CHL) is an inactive, partially capped and lined 26 acre facility located approximately 1 mile northwest of Lily Pond. The site has generally been used for the disposal of municipal solid waste and construction and demolition waste. It stopped receiving waste in 1998. Contaminants typical of this landfill include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), petroleum hydrocarbons, polychlorinated biphenyls (PCBs), metals, and nitrates (Norfolk Environmental 1998). A number of wells are in place to monitor the movement of contaminants that leach out of the landfill.

A report published by Norfolk Environmental (1998) documented maximum contaminant level exceedences of both VOCs and 1-4-dichlorobenzene, which may threaten the surrounding wetlands and Lily Pond. Migration of these contaminants through bedrock fractures was confirmed by Norfolk Environmental. Lead concentrations in sediments from Brass Kettle Brook were found to be approaching the Massachusetts Department of Environmental Protection's threshold concentration. Elevated lead concentrations were also measured in the water in Brass Kettle Brook and in an unnamed tributary at the base of the landfill, suggesting lead from the landfill was migrating downstream. As a result of these exceedences, a leachate collection trench was installed to prevent contaminants from leaching offsite into the watershed (Norfolk Ram Group 2002). Subsequent monitoring indicate that this measure has been successful. Plans are currently underway to reduce the volume of leachate generated through final capping of the landfill and to further characterize the potential impacts of the landfill on the downstream watershed.

Golf course. The care and maintenance of heavily landscaped areas, such as a golf course, are recognized sources of nonpoint water pollution. Typical practices on these lands include regular treatments with fertilizers and pesticides. "Consideration of the potential for exposure and toxic effects of applied fertilizers and pesticides should be an important component of golf course policy decisions," (USEPA 1993). Some of the environmental issues pertaining to golf course management are concerned with: (1) the extent of nutrient and pesticide applications, (2) potential for exposure of non target organisms to applied chemicals, (3) irrigation practices, (4) transport of applied chemicals off the site, and (5) impact of turf maintenance on wetlands habitat (USEPA 1993). Appendix C provides a list of contaminants frequently associated with golf course operations.

The Hatherly Country Club is situated on over 170 acres of waterfront property in northeast Scituate. The course consists of approximately 20 acres of fairway, 3 acres of greens, 2 acres of tees, and 60 to 70 acres of rough (Caughey 2002). The remaining acreage is woodland area and country club building grounds. The golf course is not considered well-manicured, as far as golf courses are concerned, but is "a more rustic, seaside-type course," (Caughey 2002). The greens, fairways, and rough are mowed as needed, and a 100-foot buffer zone is maintained between the golf course and the waters edge in most places (Caughey 2002). The turf is maintained with low volumes of fertilizer. General use pesticides are applied as needed in conjunction with an integrated pest management plan produced by the University of Massachusetts Extension Service. Recycled/recaptured grey water is used to clean maintenance equipment (Caughey 2002).

Plymouth County Mosquito Control maintains mosquito ditches throughout the golf course's drainage area, ensuring proper flow; they also spray for mosquitos as necessary (Thorndike 2002). Mosquito insecticides are applied by Mosquito Control in both Scituate and Cohasset. Resmethrin is used to kill adult mosquitos and is applied when public complaints are high and when landing count rates indicate spraying is warranted. Mosquito Control sprays for adult mosquitos between Memorial Day and Labor Day, unless additional spraying is requested by the Massachusetts Department of Public Health. Bti (*Bacillus thuringiensis israelensis*) is used as a larvicide throughout the year and applied either in liquid or pellet form (Thorndike 2002). Mosquito Control recently began treating catchbasins for West Nile Vile irradication. Best management practices are also employed, including Open Marsh Water Management to eliminate stagnant water, remove invasive species, and improve fish habitat (Plymouth County 2002).

9.5 ON-SITE SEWAGE DISPOSAL

Absent the ability to dispose of domestic sewage and other liquid waste via a sewer system and wastewater treatment plant, it must be disposed of on-site. When on-site sewer systems—such as septic tanks, absorption fields, cesspools and the like—are functioning properly, they can process wastewater containing pathogens, organic and inorganic solids, nutrients and chemicals and recycle clean water back into the natural environment. When they are malfunctioning, on-site systems are not able to properly filter contaminants and are a source of water pollution. Symptoms of a malfunctioning system include wet spots, slow drainage, foul odors, and sewage back-ups. Age and maintenance (i.e., repair, replacement, and cleaning) are key factors determining how well an on-site system works.

On-site sewage disposal systems are regulated according to the Massachusetts Department of Environmental Protection's 1995 revisions to Title 5 of the state Environmental Code, 310 CMR 15.000. Title 5 regulations require that on-site systems comply with state-mandated design and performance standards. The regulations require that private on-site systems be inspected when a property is sold or when there is a change in use or expansion of use on the property. Title 5 also establishes a comprehensive system for the review and approval of alternative technologies such as recirculating sand filters and humus/composting systems. Figure 9-1 shows the Title 5 setback requirements for new on-site septic systems.

A Title 5 inspection is required when a house or facility is to be sold to new owners or there is a transfer of title. The inspection must occur within two years prior to a transfer of title to the facility or 6 months after the sale if weather conditions preclude prior inspection. If the system fails inspection, the system must be upgraded or replaced within 2 years of the inspection regardless of whether the house is actually sold or transferred. Inspections required in connection with a transfer of title to a facility generally are good for two years. Systems serving condominiums consisting of five or more units must have been inspected prior to December 1, 1996, and then every three years. Systems serving smaller condominium developments must be inspected at time of unit transfer. Shared systems must be inspected annually and large systems (10,000 to 15,000 gallons per day design flow) every five years. When facilities are divided or combined, inspection is also required. Systems located in cities and towns with DEP-approved inspection programs will be required to comply with those local programs, rather than the inspection at transfer requirement (DEP website).

Scituate Title 5.
Within the Gulf River watershed, all of the properties in Scituate have on-site sewage disposal systems (Sullivan 2002). In order to assess the degree of compliance with Title 5 regulations regarding subsurface sewage disposal systems, it was necessary to turn to the records held by the Town of Scituate. These records are stored at the Town Hall and contain information pertaining to the sewage treatment systems on each parcel of land. As it was not feasible to study all the records, a sub-sample of 126 parcels was selected. The 126 parcels were selected on the basis of their proximity to the Gulf River estuary.

From the records, it was noted if a parcel had been issued with a Certificate of Compliance or a Subsurface Sewage Disposal System Inspection Form. If a parcel had either of these on record, it meant that an engineer had, at one time, inspected the system. However, it did not mean that the parcel was Title 5 compliant. Parcels that complied with Title 5 regulations were issued with a certificate that stated this. These were also noted.

Each parcel on which there was a file fell into one of three categories. It was either pending approval, had been approved but the septic system had not been constructed or the system had been approved and construction completed. Files were only available for 46 (or 37%) of the 126 parcels of the sub-sample. The files showed that, 27 (or 59%) of these had systems that had been inspected by an engineer and 12 (or 26%) of the 46 were in compliance with Title 5 regulations. Most of the files were for completed systems.

It is important to note that, while 26% of these parcels were in compliance with Title 5, it cannot be assumed that this percentage would also hold true for all the parcels within the Town of Scituate. No files existed on 63% of the sub-sample of parcels. This may mean that 80 of the 126 parcels were still using old systems that were constructed prior to when records had to be kept. If this were the case, the number of non-compliant parcels may have been as high as 115 of the sub-sample of 126. This would mean that only 10% of the parcels were in compliance with Title 5 at the time the information was gathered.

However, it is also possible that some of the sub-samples of parcels that were selected may not have had files on them as the compliance certificates may have been issued before the sub-divisions were designated. If this were the case, more than 12 parcels may have been in compliance. It was therefore difficult to produce a robust estimation of the percentage of parcels around the Gulf River estuary that had subsurface sewage disposal systems that complied with Title 5 regulations. It is likely that the figure was somewhere between 10 and 26%. The significance of this is that between 74 and 90% of parcels in the area may have had systems that did not comply with Title 5 and these would probably include old cesspool systems.

It is important to note that, unless there are signs of hydraulic failure, or there is an increase in design flow (for example, due to adding a bedroom to a house or increasing the seating capacity of a restaurant), a cesspool does not require a Title 5 inspection.

The Town of Scituate does not have a DEP-approved inspection process and so Title 5 inspections are likely to only occur when existing systems fail, properties are expanded or when properties are sold. Therefore, it can be expected that the number of parcels utilizing older cesspools will not be accurately known and that this number will only be reduced slowly over time.

Cohasset Title 5
As it was not feasible to study the records for all the parcels in the Town of Cohasset, a sub-sample of 113 parcels, all located close to the Gulf River, were selected. The details of these parcels were given to the Cohasset Board of Health, who then retrieved the required information from their database.

The records showed that 57 (50%) of the 113 parcels were connected to a municipal sewerage system and of these, 36 had been connected during 2001 and 2002. A further 23 parcels were scheduled to be connected in the future but were still, at the time, on septic systems.

Six of the selected parcels were vacant. Therefore at the time of the study, there were 50 parcels that were occupied and that were not connected to the sewerage system. Of these, 13 (26%) had systems that complied with Title 5 regulations and another was in the process of upgrading to a Title 5 compliant system. Once this was in compliance the percentage would increase to 28%. Six (12%) were on septic systems that had been constructed or upgraded between 1974 and 1999. Two (4%) were known to be using old cesspools and there were no data for 5 (10%) of the parcels.

Assuming that the parcels for which there was no information did not have non-compliant systems, 28% of parcels in the area would be Title 5 compliant. However, once the scheduled connection of the 23 parcels to the municipal sewerage system was completed, the percentage of compliant parcels would increase to 52%. This would leave only 13 parcels, of the 113 selected that would not be compliant.

The situation in Scituate was very different. There was no municipal sewerage system and only between 10% and 26% of the parcels within the sub-sample were in compliance with Title 5.

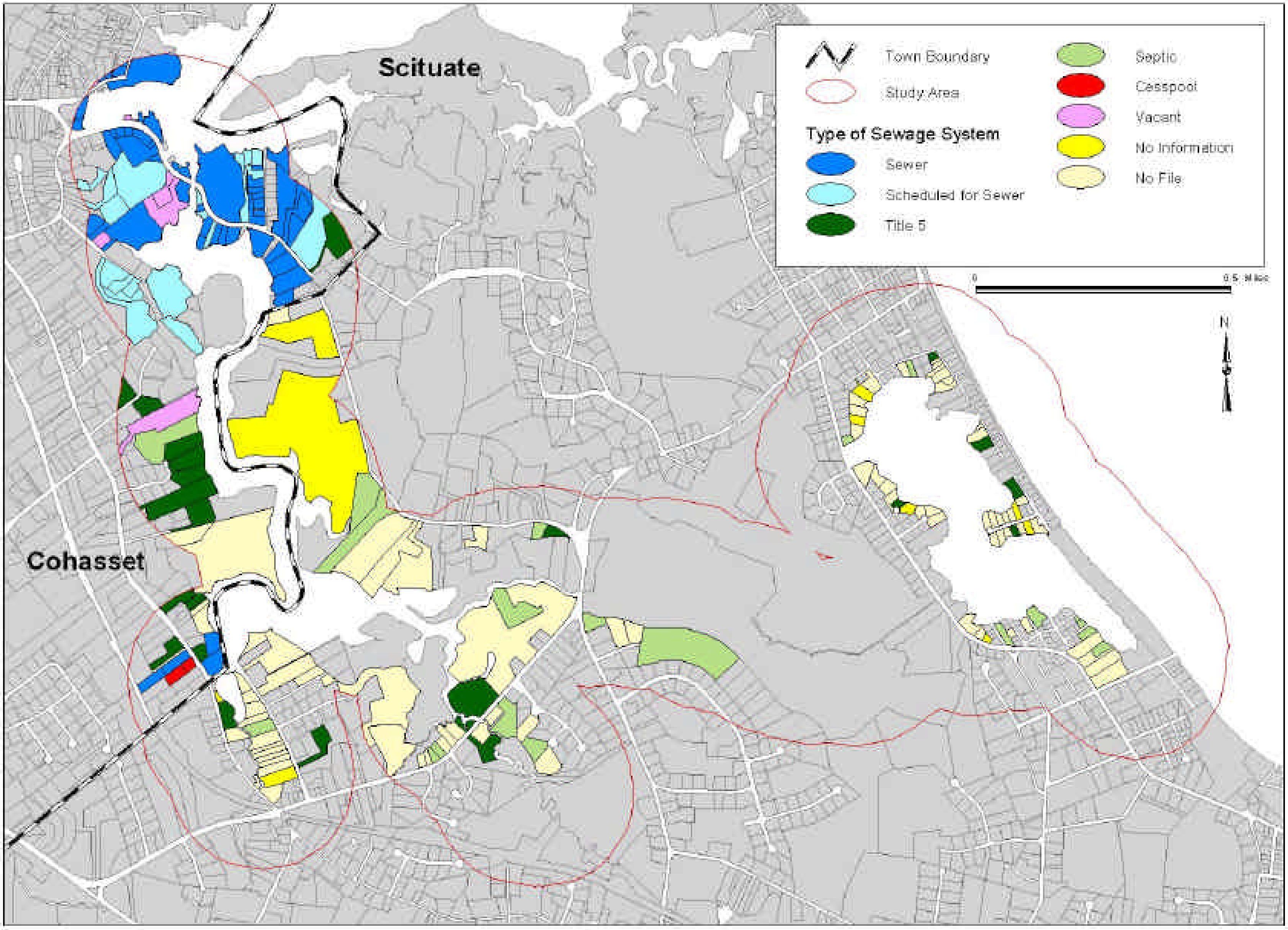

Figure 9-2. Types of Sewage Disposal Systems for Sub-sample of Parcels in Vicinity of Gulf River Estuary.

9.6 NONPOINT POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) SITES

In response to the 1987 Amendments to the Clean Water Act, the U.S. Environmental Protection Agency (EPA) developed Phase I of the NPDES Storm Water Program in 1990. Phase I addressed sources of storm water runoff that had the greatest potential to negatively impact water quality. Under Phase I, EPA required NPDES permit coverage for storm water discharges from: (1) "medium" and "large" municipal separate storm sewer systems (MS4s) located in incorporated places or counties with populations of 100,000 or more; and (2) 11 categories of industrial activity, one of which is construction activity that disturbs five or more acres of land.

Operators of the facilities, systems, and construction sites regulated under the Phase I NPDES Storm Water Program can obtain permit coverage under an individually-tailored NPDES permit (developed for MS4s and some industrial facilities) or a general NPDES permit (used by most operators of industrial facilities and construction sites). NPDES certification is issued when it is determined that the permit and all conditions imposed upon it will achieve compliance with sections 208(e), 301, 302, 303, 306, and 307 of the Clean Water Act, and with the provisions of the Massachusetts Clean Waters Act (MGL[11] c.21, s.26-53) and the associated regulations. There are three NPDES permit sites in the Gulf River watershed: (1) Cohasset's wastewater treatment plant, (2) Golden Rooster Restaurant, and (3) Cohasset Drinking Water Treatment Plant.

Cohasset Wastewater Treatment Plant. Cohasset's wastewater treatment plant is located on Elm Street near downtown Cohasset. The facility was recently upgraded in 2000 to a 0.3 million gallons per day (MGD) advanced secondary wastewater treatment plant (as a comparison, the Deer Island Wastewater Treatment Plant processes 373 MGD). Expansions and upgrades to the facility were numerous, including the addition of (1) a membrane filtration system that removes solids more effectively and improves nitrification, (2) a back-up generator, (3) an anoxic tank that allows denitrification of the waste water, and (4) an ultraviolet disinfection chamber (USEPA 1997). As well as facility and capacity improvements, the outfall pipe was relocated from James Brook to Cohasset Cove and Cohasset Harbor where the discharge is directed towards a federal navigation channel (USEPA 1997).

The Massachusetts Department of Environmental Protection (DEP) issued water quality certification to the Cohasset Sewer Commission pursuant to Section 401(a) of the Federal Clean Water Act and 40 CFR[12] 124.53 for the Cohasset wastewater NPDES permit. "According to 40 CFR 122.44(l), when a permit is reissued, effluent limitations, standards, or conditions must be at least as stringent as the final effluent limitations, standards or conditions in the previous permit…". Whether or not a facility is compliant with its NPDES permit is determined based on environmental monitoring of particular parameters.

At the time of this report, there had been no violations associated with the effluent discharge. Cohasset Harbor is designated class SA according to the Massachusetts Surface Water Quality Standards. The numerical limitations for dissolved oxygen, temperature, pH, fecal coliform, solids, color and turbidity, oil and grease, and taste and odor are presented in Table 6-1. Limitations for biological oxygen demand (BOD)[13] and Total Suspended Solids (TSS)[14] for secondary treated wastewater are defined in 40 CFR 133.102. Domestic sources of wastewater also contribute toxins to their receiving waters, including metals,

11 Massachusetts General Laws
12 Code of Federal Regulations
13 BOD is a measure of the amount of dissolved oxygen lost as a result of organic inputs into the water. Human wastewater contains a certain amount of biodegradable organic matter. Microbes in the water break down these complex organic molecules into simpler, more stable end-products such as carbon dioxide, water, phosphate, and nitrate. Dissolved oxygen in the water column is an essential ingredient in this conversion. If too much organic matter is present, then the demand for oxygen by microbes will be high, resulting in a drop in dissolved oxygen that might otherwise be available for other living organisms.
14 TSS are solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. High TSS can block light from reaching submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down, causing less dissolved oxygen to be released into the water by plants. High TSS can also cause an increase in surface water temperature because the suspended particles absorb heat from sunlight. This can cause dissolved oxygen levels to fall even further because warmer waters can hold less oxygen.

chlorinated solvents, aromatic hydrocarbons, and others. As part of the Cohasset NPDES permit, toxicity testing for lead, carbon, and total residual chlorine is required. The suite of parameters monitored by the Cohasset plant, as well as the monitoring frequency and the most recent monitoring results published are presented in Table 9-1.

Table 9-1. Water Quality Standards for Cohasset Wastewater Treatment Plant Effluent.

PARAMETER	STANDARD	MONITORING FREQUENCY	MEASUREMENTS (MAY 2002)
pH	In the range of 6.5 – 8.5	Daily	6.5 – 7.0
Fecal Coliform	Open shellfishing allowed: Not to exceed mean MPN of 14 col/100 ml No shellfishing: Not to exceed mean MPN of 200 col/100 ml, and no more than 10% samples exceed 400col/100 ml.	3/Week	1col/100 ml
BOD_5	Monthly average: 30 mg/l or less Weekly average: 45 mg/l or less	Weekly	8.25 mg/l monthly average
TSS	Monthly average: 30 mg/l or less Weekly average: 45 mg/l or less	Weekly	1.8 mg/l monthly average
Ammonia + Ammonium	None	Weekly	3.1 mg/l
Total Nitrogen	None	Weekly	5.6 mg/l

Golden Rooster Restaurant. A 2,800-gallon per day sludge waste treatment facility is located at the Golden Rooster Restaurant, 78 Border Street, North Scituate. Raw wastewater generated on-site is aerated and clarified and disinfected with chlorine tablets prior to passing through sand filters. Waste water is discharged via an outfall pipe in the Gulf River (see Figure 9-1 for approximate location). Sewage sludge is collected and transported in liquid form to an incineration facility in Cranston, Rhode Island.

A NPDES permit for this facility was granted in September 1999, superseding the 1975 permit; it is valid until November 2004. Under Massachusetts' new watershed permitting approach, major and minor NPDES permits within a designated basin are reviewed during a given year. NPDES permits for the South Coastal watershed will be reviewed in 2003. "The advantage to this approach is that the collective contribution of pollutants in a given watershed are examined once every five years," (USEPA 1999).

NPDES permit requirements call for routine monitoring and reporting of the results to the US Environmental Protection Agency. Monitoring frequency and discharge effluent limitations, based on state water quality standards, are presented in Table 9-2. No violations are apparent in the monitoring to date, although EPA does consider this treatment plant to be a run-down facility (Davis 2002).

Table 9-2. Water Quality Standards for the Golden Rooster Treatment Plant

PARAMETER	STANDARD	MONITORING FREQUENCY	MEASUREMENTS (JUNE 2002)
pH	In the range of 6.5 – 8.5	Weekly	6.9
Fecal Coliform	Class-SB: Not to exceed mean 88 colonies/100 ml.	Daily	<10 col/100ml
BOD_5	Monthly average: 30 mg/l or less Weekly average: 45 mg/l or less	Weekly	9.2 mg/l
TSS	Monthly average: 30 mg/l or less Weekly average: 45 mg/l or less	Weekly	4.8 mg/l
Total Residual Chlorine	0.0075 mg/l	Daily	0 mg/l

9.7 SEA FOAM

Local residents have witnessed increased quantities of foam in the harbor area over the past year (see Figure 9-3). While the specific identity of what is dissolved in the water to create the foam is unconfirmed, it is important to understand that any aqueous solution containing dissolved organic matter (proteins, lignins, and lipids) can form foam. Further, the organic matter that forms foam seen along shorelines is generally not generated there. More commonly, an algal bloom offshore will dissolve a large amount of organic matter in seawater, and as this water is transported onshore by winds and then agitated in the surf zone—or in the reversing falls as the case may be—foams will form. Higher concentrations of organics will typically cause foam to be thicker and longer-lasting. If foam is thick and persistent, that will give it a greater ability to trap particulates, which are likely to affect the color of the foam. This is not to say that some anthropogenic substances are not present in the foam that is seen near shore. One way to qualify whether sea foam has domestic origins is if it has a perfumed smell. While not conclusive, sea foam collected in Cohasset Cove did not have any unnatural odor.

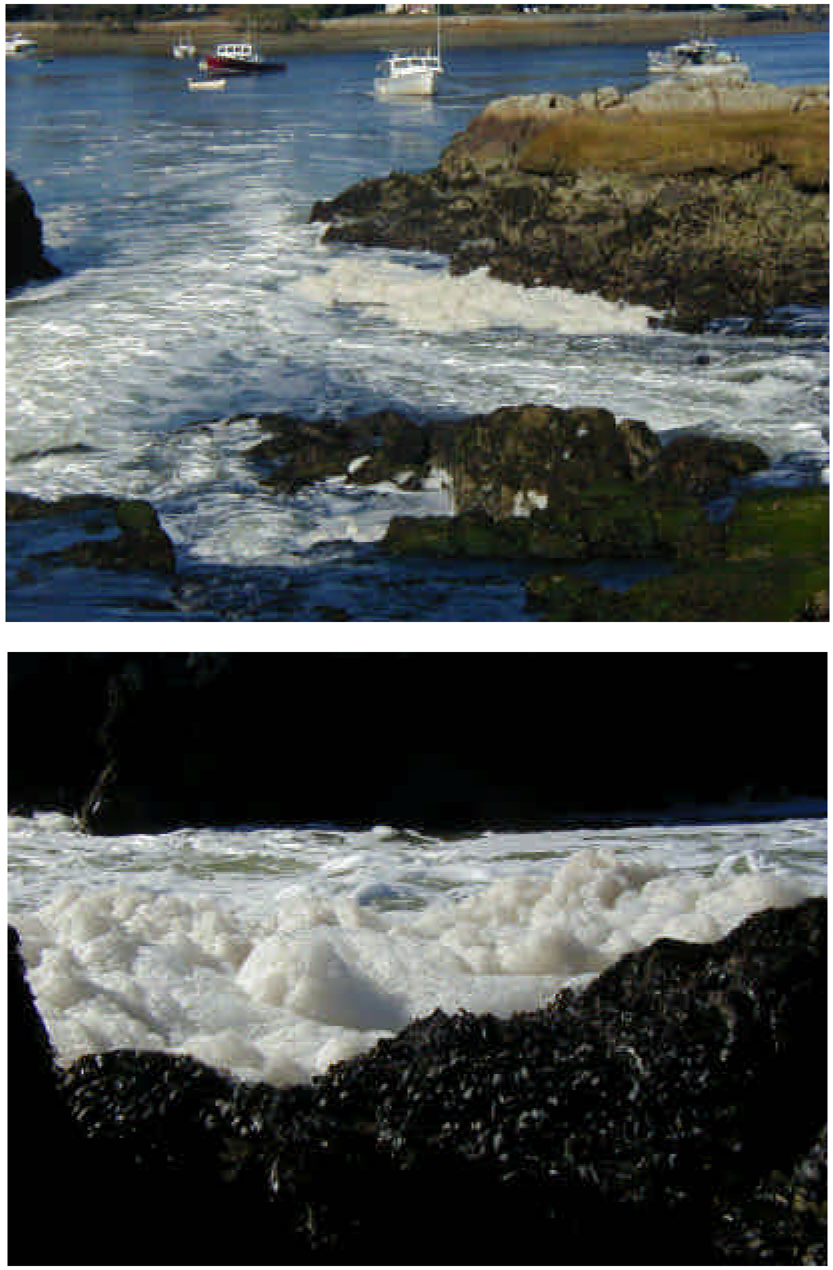

Figure 9-3. Sea Foam formed near reversing falls in Cohasset Cove (October 2002).

9.8 ALGAE

In the spring 2002, an unfamiliar species of green filamentous algae appeared in the Gulf River (Figure 9-4). The algae first appeared in late March 2002 and were still present during a site visit in July 2002. It is characterized as yellowish green with prostate filaments that were twisted together in masses. Samples of the algae and an examination of the underside of the algal mats using an underwater scope revealed that the algae were unattached and free-floating. The algae were concentrated in elbows of the river where it would collect as a result of the Gulf's current. Using a dichotomous key for identifying seaweed, it was determined that the seaweed is of the genus *Chaetomorpha*, either *Chaetomorpha linum* or *Chaetomorpha brachygona* (Villalard-Bohnsack 1995). *Chaetomorpha* is a native algae common in the northeastern U.S..

C. linum is the most common of the six species of *Chaetomorpha* found in New England and is known to behave perennially (Sheath & Harlin 1988). A conclusive determination of species could not be justified without observing features under a microscope.

Non-invasive aquatic plants are a natural and important component of aquatic ecosystems. They provide food, protective cover, nesting sites, and habitat. In addition, aquatic plants can improve the appearance and quality of water. However, given an imbalance and/or excessive supply of nutrients, aquatic plants can grow vigorously and become a nuisance, decreasing water quality and reducing fish populations. They can also deter from recreational uses of the water.

Figure 9-4. Filimentous Green Algae in Gulf River (July 2002).

It is generally not immediately obvious when aquatic plants are a problem and when they are not. Further, if they are a problem, it is difficult to conclude whether the cause is related to water quality or to some other environmental change. A new development, for example, might open more of the shoreline to increased sun exposure, which in turn increases rates of photosynthesis and plant growth. There is also the problem of perception; what constitutes too many weeds is highly subjective. Since the algae in the Gulf tend to collect in pockets close to the shoreline, it has minimal impact on boaters. However, someone fishing from the shore is more likely to find that the density of weeds is a hindrance. And others might find weeds that form mats are unsightly and, therefore, a problem in their minds.

Two important questions to address in assessing aquatic vegetation are: (1) Is the species non-native? and (2) has there been a change in diversity or extent of the plants normally present (i.e., is this plant taking over)? In the case of the Gulf algae, the genus of algae identified is native. In addition, there is some anecdotal evidence that suggests these weeds have appeared in the Gulf River before, but not for many years. Many plants have natural cycles where extensive growth occurs when conditions are optimal for them. It is possible that the Gulf River has a naturally variable population of *Chaetomorpha* and that conditions in 2002 were optimal for growth. Absent more detailed information on the Gulf's plant community or any nutrient data, it is impossible to make more specific determination at this time.

9.9 STORM WATER

Rain water that flows overland or through storm drains and does not get absorbed into the ground is called *storm water* or *runoff* and is a form of nonpoint source pollution. Storm water is a leading source of water pollution. Common pollutants associated with storm water include oil and grease (e.g., from vehicles, machinery, kitchen waste), heavy metals (e.g., from batteries, paints, pesticides), nutrients (e.g., fertilizers, animal waste), chemicals (e.g., from cleaning products, pesticides), sediment (e.g., from construction sites), litter (e.g., improperly disposed trash), and bacteria (from failing septic systems, animal waste).

Impervious surface is an important factor in determining the quality and quantity of storm water flowing within and between the different waterways in a watershed. As more area within a watershed is covered by surfaces that shed water rather then absorb it, the volume and velocity of storm water runoff carrying pollutants to streams, ponds, lakes, and the ocean increases. Using impervious surface coverage to evaluate environmental impacts from storm water offers a cost-effective and realistic approach because these surfaces can be measured, managed, and controlled (Sleavin *et al*. 2000).

Section 7 estimated that approximately 7.3 percent of the Gulf River watershed is impervious surface, with the greatest amount of imperviousness concentrated closer to the coastline. According to a three-tier classification scheme suggested by Schueler (1994), land area with less than 10 percent impervious coverage is considered protected, 10 to 25 percent is considered impacted, and 25 percent or more is considered degraded. Considering the Gulf River watershed as a whole, it would be classified as protected. However, given the concentration of impervious coverage on the eastern side of the watershed, it is necessary to weigh the environmental impacts on a smaller scale. Figure 7-2 illustrates the impervious coverage for the watershed. Land area just south of the Gulf River, for example, has surfaces with 20 percent impervious coverage, and should be considered as impacted. Land around Musquashchut Pond is also heavily built with 20 to 50 percent impervious coverage, which would classify it as degraded.

Towns throughout Massachusetts are presently in the process of preparing for implementation of a new phase in storm water control. The US Environmental Protection Agency's storm water management program, initiated in 1990 under the Clean Water Act, is aimed at preserving, protecting and improving the Nation's water resources from polluted storm water runoff. The first phase of the program focused on using the National Pollutant Discharge Elimination System (NPDES) permits to address storm water runoff from larger storm sewer systems serving populations of 100,000 or more and construction activities disturbing five acres or more and certain industrial activities. Phase II, which began in 1999, extended the NPDES permit coverage for storm water discharges from smaller storm sewer systems (under 100,000 population) in urbanized areas and smaller construction sites (activities disturbing between one and five acres of land. Phase II is an attempt to further reduce adverse impacts to water quality and aquatic habitat through the use of controls such as public educational programs, storm sewer inspections for illegal connections, and ordinances to control construction site runoff.

9.10 HAZARDOUS SPILL SITES

RCRA Corrective Action Sites. The Resource Conservation and Recovery Act (RCRA) program requires facilities that have treated, stored, or disposed of hazardous wastes to clean up environmental contaminants released into soil, ground water, surface water, or air regardless of when they were released. This cleanup is known as a RCRA Corrective Action. Within the Gulf River watershed, two RCRA Corrective Action Sites have been identified: (1) Norfolk Conveyor (Seavy Engg and H&W Ind), 155 King Street, Cohasset; and (2) Wompatuck State Park, Rte 3A, Hingham. Specific information on the activity and contamination at these sites is described in Appendix D.

Federal CERCLA (Superfund) Sites. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as the Superfund Act of 1980 and amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, holds owners and operators of facilities that release hazardous wastes liable for the costs of cleanup. Superfund also provides a mechanism for identifying liable parties and holding them accountable.

The National Priorities List (NPL) is part of the Superfund process. Sites are listed on NPL upon completion of Hazard Ranking System (HRS) screening, public solicitation of comments about the proposed site, after all comments have been addressed, and after responsible parties have been identified. Once a site is listed on the NPL, it becomes a priority to study the type and extent of contamination, evaluate options and cleanup plans, and ultimately, to clean up the site. Within the Gulf River watershed, there are two Superfund properties; both are awaiting decision on NPL listing: (1) Norfolk Conveyor, 155 King Street, Cohasset; and (2) Wompatuck State Park, Rte 3A, Hingham. These are the same sites identified as RCRA Corrective Action sites. The reason is that RCRA deals with currently active facilities and CERCLA deals with sites that were contaminated by companies or activities that are no longer on site. Both Norfolk Conveyor and Wompatuck State Park have a history of contamination, as well as current hazardous waste generating uses.

Massachusetts 21E Sites. Enacted in 1983, the state Superfund Statute, the Massachusetts Oil and Hazardous Material Release Prevention and Response Act (Massachusetts General Law Chapter 21E), establishes the state’s authority to ensure the permanent cleanup of oil and hazardous material releases (i.e., spill sites), determine who is legally responsible for them, and require responsible parties to do the work or reimburse the Commonwealth for cleanup costs. DEP implements the 21E program through a set of regulations known as the Massachusetts Contingency Plan (MCP). MCP describes the rules for conducting cleanups of contaminated sites.

Amendments to MCP regulations in 1992 enabled the participation of Licensed Site Professionals (LSPs)—licensed environmental experts with a certain level of competence in site assessment and cleanup. The inclusion of LSPs reduced DEPs responsibilities under Chapter 21E, helping speed up the cleanup process. LSPs can be hired by responsible parties to manage cleanups and ensure that site work meets state requirements.

Sites that are not cleaned up within one year are scored using the MCP’s Numerical Ranking System (NMS) to determine the additional level of DEP oversight required. The spill sites are then classified as Tier I or Tier II. Tier I sites require a permit to proceed with (Tier IA) or without (Tier IB) direct DEP oversight. Tier II sites can proceed with cleanup without DEP involvement.

Table 9-1 present a comprehensive collection of oil and hazardous waste spill sites (21E sites) identified in the Gulf River watershed (DEP 2002). Figure 9-1 represents those 21E sites still considered active. The maps were adapted from data obtained from the Massachusetts Department of Environmental Protection (DEP) Bureau of Waste Management. There are 73 sites listed within the watershed, although only 16 are currently active with the remaining spill sites having been remediated.

Table 9-3. 21E Sites in Gulf River Watershed

ID	Address	Town	Notification Date[15]	Reporting Category[16]	Compliance Status	Chemical Type
1	Pond St. (at spring street)	Cohasset	5/5/1997	2 hour	RAO[17]	Oil
2	Beechwood Dump, Doane St.	Cohasset	9/28/2000	120 day	Tier IB	Hazardous Material
3	22 Depot ct.	Cohasset	10/15/1989	none	Tier IB	Oil
4	828-860 Chf.Justice Cushing Hwy	Cohasset	7/1/1997	120 day	RAO	Hazardous Material
5	828-860 Chf.Justice Cushing Hwy	Cohasset	7/23/1998	120 day	RAO	Hazardous Material
6	143 Pond St.	Cohasset	1/15/1990	none	RAO	
7	380 Chf. Justice Cushing Hwy	Cohasset	11/16/2001	120 day	RAO	Hazardous Material
8	151 South Main St.	Cohasset	9/26/1991	none	Tier IB	Oil
9	740 Chf. Justice Cushing Hwy	Cohasset	11/20/1995	120 day	RTN Closed[18]	Hazardous Material
10	740 Chf. Justice Cushing Hwy	Cohasset	2/9/1996	72 hour	RTN Closed	Oil
11	25 Wood Way	Cohasset	9/17/1996	2 hour	RAO	Oil
12	754 Chf. Justice Cushing Hwy	Cohasset	7/15/1993	none	RAO	
13	Eastern Edison, Beechwood St.	Cohasset	3/14/1998	2 hour	RAO	Oil
14	395 North Main St.	Cohasset	7/15/1993	none	RAO	Oil and Hazardous Material
15	740 Chf. Justice Cushing Hwy	Cohasset	4/4/1995	120 day	RTN Closed	Oil
16	740 Chf. Justice Cushing Hwy	Cohasset	10/1/1993	none	RAO	Oil
17	Farmer Brown's Auto, Depot Ct.	Cohasset	4/7/1995	120 day	Def. Tier IB	Oil
18	190 King Dr.	Cohasset	1/15/1992	none	RAO	
19	405 North Main St.	Cohasset	4/28/1989	none	RAO	Oil
20	430 South Main St.	Cohasset	1/15/1987	none	DEPNDS[19]	
21	30 Crocker Ln.	Cohasset	12/4/1998	72 hour	RAO	Oil
22	Crocker Lane off Rt. 3A	Cohasset	11/20/1998	72 hour	RAO	Oil
23	Crocker Lane off Rt. 3A	Cohasset	3/28/2002	120 day	Unclassified[20]	Oil

[15] The date DEP uses to establish 21E deadlines, which is usually the date when the site/release was reported the DEP; for some it may be later.

[16] Refers to how quickly a release must be reported to DEP, which is dictated by the potential severity.

[17] RAO (Response Action Outcome) refers to a site/release where an RAO Statement was submitted. An RAO statement asserts that response actions were sufficient to achieve a level of no significant risk or at least to ensure that all substantial hazards were eliminated.

[18] RTN CLOSED means that any additional response actions to address the release at this site will be conducted as part of response actions planned for the site under a different release tracking number (RTN).

[19] DEPNDS, DEP Not a Disposal Site, means that DEP has determined that these locations did not need to be reported and are not disposal sites.

[20] UNCLASSIFIED means that a release has not reached its Tier Classification deadline (usually one year after release reported) because an RAO Statement, DPS Submittal, or Tier Classification Submittal has not been received by DEP.

ID	Address	Town	Notification Date[15]	Reporting Category[16]	Compliance Status	Chemical Type
24	805 Chf. Justice Cushing Hwy	Cohasset	10/15/1988	none	RAO	
25	13 North Main St.	Cohasset	2/16/1994	2 hour	RAO	Oil
26	60 South Main St.	Cohasset	9/27/1995	120 day	DPS[21]	Oil and Hazardous Material
27	56-60 South Main St.	Cohasset	9/27/1995	120 day	RAO	Oil
28	231 South Main St.	Cohasset	8/23/1996	72 hour	RAO	Oil
29	1&3&5 South Main St.	Cohasset	1/23/1997	120 day	DPS	Hazardous Material
30	6 Schofield Rd.	Cohasset	5/9/1997	72 hour	RAO	Oil
31	21 Norfolk Rd.	Cohasset	9/19/1997	120 day	RAO	Oil
32	30 Hammond Ave	Cohasset	5/15/1998	2 hour	RAO	Oil
33	30 Hammond Ave	Cohasset	6/14/1998	2 hour	RAO	Oil
34	217 South Main St.	Cohasset	11/11/1998	2 hour	RAO	Oil
35	272 Beachwood St.	Cohasset	7/7/1999	2 hour	RAO	
36	72 Elm St.	Cohasset	9/24/1999	72 hour	RAO	Oil
37	Summer and South Main Streets	Cohasset	10/28/1999	120 day	Def Tier IB[22]	Oil
38	114 Beechwood St.	Cohasset	8/4/2000	2 hour	RAO	Oil
39	20B Norfolk Lane	Cohasset	9/14/2000	2 hour	RAO	Oil
40	55 South Main St.	Cohasset	9/20/2000	2 hour	RAO	Oil
41	35 Arrowood Rd.	Cohasset	4/12/2002	2 hour	RAO	Oil
42	40 Border St.	Cohasset	1/15/1989	none	DEPNFA[23]	
43	40 Border St.	Cohasset	11/20/1996	2 hour	RAO	Oil
44	181 Border St.	Cohasset	4/22/1999	2 hour	RAO	Oil
46	Pole #16, King St.	Cohasset	10/24/1993	2 hour	RAO	Oil
46	827 Chf. Justice Cushing Hwy	Cohasset	1/15/1987	none	LSPNFA[24]	
47	56 Spring St.	Cohasset	1/15/1991	none	RAO	Oil
48	215 South Main St.	Cohasset	10/1/1993	72 hour	RAO	Oil
49	44 Border St.	Cohasset	3/9/1988	none	DEPNFA	Oil
50	800 Chf. Justice Cushing Hwy	Cohasset	4/1/1999	120 day	RAO	Oil
51	155 King St.	Cohasset	11/6/1993	2 hour	RAO	Hazardous Material
52	740 Chf. Justice Cushing Hwy	Cohasset	12/1/1994	72 hour	RAO	Oil
53	828 Chf. Justice Cushing Hwy	Cohasset	1/15/1989	none	RAO	
54	109 South Main St.	Cohasset	9/16/1994	72 hour	RAO	Oil
55	391 Chf. Justice Cushing Hwy	Cohasset	1/17/1989	none	DEPNFA	
56	1 Pleasant St.	Cohasset	7/12/1994	72 hour	RAO	Oil
57	55 Main St.	Cohasset	6/28/1993	none	Def Tier IB	Oil

21 DPS (Downgradient Property Status) is a site where a DPS submittal to DEP has stated that contamination on the property is coming from an upgradient property.

22 DEF TIER 1B (Default Tier 1B) applies to a spill where the responsible party fails to provide a required submittal to DEP by a specific deadline.

23 DEPFNA (DEP No Further Action) means that response actions were conducted and DEP determined no further action was needed for the site.

24 LSPNFA (License Site Professional No Further Action) means that response actions were conducted and an LSP has determined that no further action was needed for the site.

ID	Address	Town	Notification Date[15]	Reporting Category[16]	Compliance Status	Chemical Type
58	100 Ripley Rd.	Cohasset	11/25/1992	none	RAO	
59	155 King St.	Cohasset	1/15/1987	none	DEPNFA	
60	340 Gannett Rd.	Scituate	9/28/1995	72 hour	RAO	Oil
61	781 Chf. Justice Cushing Hwy	Scituate	7/15/1998	2 hour	RAO	Oil
62	762 Rear Country Way	Scituate	8/5/1996	72 hour	RAO	Oil
63	Gannett Rd.	Scituate	11/10/1997	72 hour	RAO	Oil
64	Bailey's Island	Scituate	12/23/1994	2 hour	RAO	Oil
65	376 Gannett Rd.	Scituate	11/8/1995	72 hour	RAO	Oil
66	68 Pratt Rd.	Scituate	4/8/1999	72 hour	RAO	Oil
67	97 Hollett St.	Scituate	5/20/1999	72 hour	RAO	Oil
68	150 Lawson Rd.	Scituate	5/12/2000	72 hour	Tier II	Oil
69	816 Country Way	Scituate	12/6/1993	2 hour	RAO	Oil
70	781 Chf. Justice Cushing Hwy	Scituate	5/16/1996	72 hour	Tier II	Oil
71	316 Hatherly Rd.	Scituate	8/21/1996	72 hour	RAO	Oil
72	7 Marshfield Ave.	Scituate	3/31/1995	72 hour	RAO	Oil
73	Pole #15, Mt. Hope Street	Norwell	1/21/1997	2 hour	RAO	Oil

9.11 GREENBUSH LINE CORRIDOR PROJECT

NOTE: Since February 2003, the state has put a hold on the Greenbush Project for six months while they review and prioritize transportation projects in the state (Foreman & Shartin 2003).

The Greenbush line is the last component of the Old Colony Railroad Rehabilitation Project to improve public rail transportation service from the South Shore to downtown Boston. Former train service from the South Shore ended in 1959, but increased transportation demands on the existing highway and transit system have necessitated reactivation of this rail service. The restoration is an approved transportation control measure of the Massachusetts State Implementation Plan, which is federally mandated by the Clean Air Act (Sverdrup Civil Inc. 2001). The Old Colony Project is part of a comprehensive state program "to encourage transit-oriented development patterns that reduce the automobile dependency such as increased need for highways and parking facilities, reduced air quality, and urban sprawl," (Sverdrup Civil Inc. 2001).

The Greenbush line was separated from the other Old Colony lines (Main, Middleborough, and Plymouth) "so that it could receive additional analysis of certain environmental issues that were raised in the Draft Environmental Impact StatementReport," (Sverdrup Civil Inc. 2001). The Greenbush line will be approximately 20 miles along an existing railway right-of-way and will service communities east of Route 3 from Duxbury to Braintree. Existing public transportation services in these areas include three commuter boat routes, commuter express buses, and local bus service.

The nature and extent of the Greenbush project required preparation of an environmental impact report by the Massachusetts Bay Transportation Authority, as mandated by the Massachusetts Environmental Policy Act (MEPA) (MGL 30 § 61-62H). Both a draft environmental impact report and final report are required to assess the full range of environmental impacts. A public comment period follows the release of each report, and the final report must address all issues raised during the public comment period of the draft report. In addition to MEPA assessment, the Greenbush project is subject to a review by the Army Corps of Engineers under Section 404 of the Federal Clean Water Act, which regulates the filling or alteration of waters and wetlands within the U.S.

The goals of the Greenbush project are to reduce travel time and congestion, reduce fuel consumption and air pollution from autos, improve water quality, preserve the natural environment, and minimize impacts on wildlife habitats (Sverdrup Civil Inc. 2001). The Final Environmental Impact Report for the project considered a number of different transportation design alternatives to achieve these goals. Each alternative was evaluated with respect to transportation effectiveness, cost effectiveness, financial feasibility, and fairness. In the end, six different alternatives were selected for evaluation: (1) no build, (2) expanded bus service and park n ride lots, (3) expanded commuter boat service and facilities at Hingham Shipyard, (4) expanded commuter boat service and facilities at Hingham Shipyard and Nantasket Pier, (5) commuter rail service to Greenbush at grade, and (6) commuter rail service to Greenbush with a tunnel through Hingham Square. Alternative (6) was the preferred alternative.

One of the passenger stations on the proposed Greenbush line will be located in North Scituate Village. No preferred alternative to this site was identified through the public comment and environmental review process. "It is approximately 5 acres in size, consisting of a main parking area on the site of the former South Shore Publishing Company, with a satellite parking area located across Henry Turner Bailey Road on the sire of town tennis courts," (Sverdrup Civil Inc. 2001). The North Scituate Station would include approximately 400 parking spaces, sufficient to accommodate projected demand, with up to 130 spaces in the satellite facility. Total trip time from North Scituate to downtown Boston will be 51 minutes; the one-way fare is estimated at four dollars.

The Greenbush line will pass through the Weymouth, Weir, North, and South river watersheds. Areas within the vicinity of the Gulf River estuary will be impacted.

> *The railroad right-of-way crosses a tributary to the James Brook associated with the Ellmo Meadow wetlands and a tributary to the Gulf. In North Scituate, the railroad right-of-way crosses Bound Brook, which flows into Hunters Pond…Passing through North Scituate, the railroad right-of-way passes through wetlands adjacent to the southern extension of Musquashcut Brook*, (Sverdrup Civil Inc. 2001).

Wetland Impacts. The North Scituate station will impact a total of four parcels: one vacant industrial building, one tennis court and its parking area, and one industrial building driveway. These parcels will be acquired by the MBTA through direct purchase and land swaps. Construction of the station will cause unavoidable impacts to 2,617 SF of palustrine scrub-shrub wetlands, mainly due to the construction of the passenger platform.

Where the right-of-way crosses Bound Brook, the existing bridge is proposed to be replaced with a large box culvert. The channel at this location will also be widened to avoid a flood problem and a compensatory flood storage area will be provided on site. Due to the widening of Country Lane, 369 SF of wetlands will be impacted at Gannet Road. The widening of Hollet Street would result in fill to 326 SF of wetlands associated with a tributary to Musquashcut Brook. Rehabilitation of the right-of-way also would result in 6,884 SF of fill to adjacent wetlands of a tributary to Musquashcut Brook. Mitigation for most of the above mentioned impacted wetlands will be provided within the Town of Scituate.

Water Quality Impacts. Storm water runoff contamination from the commuter rail station and parking lot will include motor oils and lubricants, litter, sand, and de-icing salts. Best management practices will be implemented to comply with the Massachusetts Stormwater Policy and to minimize runoff. Specific information about the types of best management practices was not provided.

Pollutants associated with railbeds include diesel fuel, lubrication oils, rust prohibitant, antifreeze, window washing fluid, and particulates of carbon, metals and brake linings. Railbed drainage system designed to prevent the railbed from flooding and producing runoff.

It will be necessary to spray herbicides as part of railroad maintenance. MBTA is required to prepare an overall vegetation management plan and a yearly operational plan for herbicide application. Specific restrictions on the use of herbicides in the vicinity of drinking water supply resources will apply.

All five states that will be impacted by the Greenbush line have negotiated multimillion-dollar settlements with the state to offset the impact (Foreman & Shartin 2003).

A copy of the certificate from the Secretary of Environmental Affairs approving the Final Environmental Impact Report is provided in Appendix E.

10. RECOMMENDATIONS FOR FUTURE WORK

(1) Improve the Gulf Association's stewardship network.

Use this natural resource inventory as a tool to reach out to local and state government officials, local residents and businesses, and existing members of the Association. Expanding the network will (a) provide education to the community that will help ensure protection of the estuary, (b) demonstrate that the Gulf Association is willing to work effectively with local and state government, and (c) confirm its commitment to long-term protection of the Gulf River estuary. Growing the Association's stewardship network should be an ongoing activity.

(2) Continue to develop water quality data.

Reliable, high quality water quality data is sparse for the Gulf River. The Association should continue its partnership with Cohasset High School for water quality monitoring. The monitoring program should be modified as necessary to provide meaningful information on the quality and quantity of inputs, sources and pathways of contaminants to the Gulf River estuary. The Association might also consider biological monitoring of the estuary. The North and South River Watershed Association could provide the expert guidance for a successful and informative monitoring program. Another good resource is the Merrimack River Watershed Study Design Workbook, which will guide any monitoring group through the basics of designing a scientific monitoring program and study design. It is available online at http://www.merrimack.org/vemn/publications.htm.

The Gulf Association and high school should develop a Quality Assurance Project Plan (QAPP) for their monitoring program to document their sampling and analytical methodology, ensure that monitoring is consistent, provide for higher quality data, and bring credibility to the data. Most agencies will not consider the findings of a monitoring program without a QAPP. At this time, the North and South River Watershed Association and Coastal Zone Management have consulted with Cohasset High School to discuss their monitoring protocol and the importance of a QAPP. A good resource is the Massachusetts Volunteer Monitor's Guidebook to Quality Assurance Project Plans available on-line at http://www.state.ma.us/dep/brp/wm/files/qapp.pdf.

(3) Research hydrology of the Gulf River estuary.

There is a lack of information concerning the flow of water in the Gulf River and its tributaries. This information is important for understanding the pathways of contaminants into the Gulf River estuary and for learning how sensitive the system is to a build-up of pollutants. The hydrology can be resolved through the use of flow meters, by calculating the watershed's water budget, and by determining the estuary's *flushing time*. A slow flushing time implies that the estuary is slow to exchange water with Cohasset Harbor (and ultimately the Atlantic Ocean) and has the potential to build-up high concentrations of pollutants. An estuary with a rapid flushing time, on the other hand, is generally considered to tolerate more pollution because they are quickly transported out of the system. An opportunity exists to begin gathering this data as part of the US Army Corps of Engineers' hydrologic study of Musquashcut Pond, which is planned for 2003 (Hatfield 2002). The Gulf Association should keep aware of this project, relay their interest, and discuss what information logically could be collected for the Gulf Association with Massachusetts Coastal Zone Management.

(4) Conduct a baseline shoreline survey of the Gulf River and its tributaries followed by periodic surveys to document change.

The Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement's Riverways Adopt-A-Stream program has developed shoreline survey guidance. It is available on-line at http://www.state.ma.us/dfwele/river/rivAAS_pubs.htm along with guidance for the stream team leader. A copy of the survey has also been provided in Appendix F. Plan for follow-up surveys to monitor visually any degradation or improvements in the environment. As part of routine surveys, the Gulf Association should document the time and distribution of algae in the river. Continuous and/or increasing growth of the filamentous algae discussed in 9.8 would suggest that additional research on the etiology of this plant is necessary.

(5) Locate failing on-site sewage systems and illegal sewage connections.

This report has identified that there are properties where the age of the septic system would suggest that the system might not be functioning properly. It also has been suggested that some properties might have failing on-site sewage treatment facilities and illegal connections. The Gulf Association should work with appropriate town officials and/or a consulting firm to address these concerns. The Gulf Association should design an education program to teach homeowners and local businesses about on-site system issues.

(6) Refine land use data.

As part of their overall goal of understanding the sources of pollution to the Gulf River estuary, the Gulf Association must keep apprised of the different land uses within the estuary's watershed. As explained on page 53 of this report, land uses can be linked to specific contaminants. The Association could improve the existing land use data available from the towns by documenting specific land uses on each parcel within their watershed. Information on past land uses would also be useful. This data can be used in combination with the Massachusetts DEP contaminant matrix provided in Appendix C to list potential contaminants of concern within the watershed.

(7) Prevent the spread of non-native, invasive plants and algae.

Nearly one-third of all plants growing wild in Massachusetts are non-native. The Gulf Association should work with the local conservation commissioners in Scituate and Cohasset to develop a plan for containing and eradicating non-native, invasive plants such as *Phragmites australis* (common reed). A good resource on the ecology and control of Phragmites was developed by the US Geological Service National Wetlands Research Center and can be found in Appendix G or on-line at http://www.nwrc.gov/wdb/pub/wmh/13_4_12.pdf.

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APPENDICES

Appendices to this report are compiled under separate cover.

APPENDIX A	Letter from National Heritage and Endangered Species Program regarding rare species in the vicinity of the Gulf River estuary
APPENDIX B	Memorandum from Division of Marine Fisheries regarding Rainbow Smelt Spawning Habitat in Bound Brook, Cohasset
APPENDIX C	Massachusetts Department of Environmental Protection Matrix of Land Use Contaminants
APPENDIX D	RCRA sites
APPENDIX E	Certificate of the Secretary of Environmental Affairs On the Final Environmental Impact Report for Transportation Improvements in the Greenbush Line Corridor
APPENDIX F	Shoreline Survey Data Sheets Shoreline Survey Estuary Data Sheets Riparian Area Survey
APPENDIX G	Section 13.4.12 Control of Phragmites or Common Reed (from USGS Waterfowl Management Handbook)